The Welfare of Captive Lion-tailed Macaques

(*Macaca silenus*)

Housed in Indian Zoos

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DECLARATION

I hereby declare that this thesis is of my own composition, and that all assistance has been acknowledged. The results presented in this thesis have not previously been submitted towards any other degree or for any other qualification.

Avanti Mallapur

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GENERAL ABSTRACT

There is a growing need for non-human primate populations in captivity to be managed using techniques based on scientific principles, so as to be able to maintain self-sustaining populations and also, if need be, successfully reintroduce these populations into their wild habitats. It is thus recognised that captive primate groups should be housed in environments in which their welfare is not compromised where they can exhibit most, if not all, of their natural social and behavioural characteristics. In order to design and maintain ideal captive environments for primates, it is important to incorporate applied animal behaviour and welfare research in the mandate of conservation breeding programmes in zoos. In this study, the behaviour of captive lion-tailed macaques in 18 Indian zoos was recorded to identify the factors that influence the behavioural repertoire of captive lion-tailed macaques. The first step was to construct a detailed ethogram; behavioural observations were then conducted using *ad libitum* sampling, focal animal sampling and instantaneous scans. Sampling was carried out only during the day when visitors were present at the macaque enclosures. The results showed that stereotypic pacing was the most commonly exhibited behavioural abnormality. Abnormal behaviours were only exhibited by confiscated and zoo-born individuals but never by wild-caught and captive-reared animals. Active foraging behaviours were influenced by enclosure complexity. In order to determine what improvements could be made to the zoo enclosures, two behavioural studies were conducted on six singly-housed captive lion-tailed macaques in Thiruvananthapuram Zoo. In Study A, cotton ropes and a feeding basket were added to the enclosures and were later removed, while in Study B, the singly-housed individuals were transferred to a large open-moated enclosure in which they were group-housed. In Study A, frequencies and proportions of abnormal behaviour exhibited differed significantly across the five phases of the study with the lowest proportions being exhibited when the macaques were fed in elevated feeding baskets. During this phase, frequencies of exploratory behaviours and other natural behaviours also increased. Self-biting exhibited by several of the singly-housed macaques appeared to be redirected towards the enrichment provided, thus reducing the overall levels of abnormal behaviour exhibited. In Study B, the six captive lion-

tailed macaques exhibited significantly greater levels of abnormal behaviour when they were housed singly in barren cages. Individuals exhibited higher levels of active foraging when they were in group-housed in the open-moated enclosure. A further study was conducted to investigate the influence of visitors' presence on captive lion-tailed macaques. The behavioural study was conducted on 35 individuals housed in 10 zoos across India. The study animals were observed on days with visitors present and on zoo holidays when there were no visitors. To record the long-term impact of visitors' presence on captive primate behaviour and welfare, another study following the same sampling method was conducted in which the behaviour of seven singly-housed individuals was recorded independently in 'on-exhibit' and 'off-exhibit' enclosures of similar sizes. Captive macaques exhibited lower levels of abnormal behaviour on zoo holidays and the frequency of begging when off-exhibit was lower as compared to days with visitors present and in on-exhibit enclosures respectively. Even social behaviour was influenced by visitors' presence, with captive lion-tailed macaques exhibiting both higher proportion of time spent in social behaviour and higher frequencies of reproductive behaviour on zoo holidays. In conclusion, the presence of visitors, enclosure design, group composition and early rearing history were all found to influence the behaviour and welfare of captive lion-tailed macaques in the study zoos. Enriching the enclosures and changing the social circumstances of the macaques were found to positively influence the welfare of the study animals, because they led to them exhibiting more natural behaviours. Indicators that were most suitable in assessing the welfare of captive lion-tailed macaques included the physical-condition factor and the developmental and reproductive success factor accounting for the highest proportion of the total variance in the population. These factors were 'non-invasive' and 'hands-off' and hence proved ideal for assessing the welfare of individuals that were part of a conservation breeding programme.

Key words: lion-tailed macaque, conservation breeding, animal welfare, enrichment, zoo, India

CHAPTER I *Literature review and aims*

CONTENTS

Relevance of applied animal behaviour and welfare studies in designing conservation breeding programmes for the endangered lion-tailed macaque

1.1. ABSTRACT

There is a growing need for non-human primate populations in captivity to be managed using techniques based on scientific principles, to be able to maintain self-sustaining populations and also, if need be, successfully reintroduce these populations into their wild habitats. It is thus recognised that captive primate groups should be housed in environments in which their welfare is not compromised and where they can exhibit most, if not all of their natural social and behavioural characteristics. In order to design and maintain ideal captive environments such as these for primates, it would be imperative to incorporate applied animal behaviour and welfare research in the mandate of conservation breeding programmes in zoos. In this chapter, the need to include applied animal behaviour and welfare research in the conservation breeding programme set up for lion-tailed macaques in Indian zoos has been addressed and the significance of long-term behaviour and welfare monitoring of breeding groups along with the provision of environmental enrichment has been emphasised.

Key words: animal welfare, conservation breeding, lion-tailed macaques, zoos, India

1.2. INTRODUCTION

Although there is often conflict between wildlife management and animal welfare principles (Jamieson 1995), zoos and conservation breeding facilities worldwide have recognised the importance of animal welfare research and are promoting such studies in their facilities (for example Stoinski *et al* 1997; Wiese & Hutchins 1997). As breeding and reintroduction are being used increasingly as a conservation strategy, animal welfare research is being carried out for successful breeding, training and intensive post-release management, as well as to prepare husbandry guidelines and meticulous scientific documentation to optimise reintroduction success for many species (Beck 1995). Studies on zoo primates have provided information to zoological societies on how to house animals in ways that meet their basic physical requirements, while providing appropriate environmental and social stimulation (Maple *et al* 1995). By implementing the results of these zoo biological studies in animal management, visitor awareness has also been achieved actively through education programmes, and passively through exhibiting animals that follow species-specific behaviour patterns.

Through conservation breeding programmes, zoo staff has the opportunity to study endangered species of primates and apply their knowledge to improving the health and welfare of these species in captivity. The first step towards breeding endangered primates is to study their free-ranging counterparts to develop a sound understanding of the species biology and behaviour (eg Lindburg *et al* 1997; Stoinski *et al* 1997; Wiese & Hutchins 1997). In the past, studies from the wild have been compared to data collected from captive populations to increase information on the species in question. Several studies have been conducted on behaviour of zoo animals (for example Buchanan-Smith 1996; Estep & Baker 1991; Fritz *et al* 1992; Mallapur & Choudhury 2003; Mallapur in press) and breeding success (Mitchell *et al* 1987; Lindburg *et al* 1989; Johnson *et al* 1991) to understand the dynamics of captive environments and the factors that influence the behavioural repertoire of captive primates. Studies such as these have helped scientists to identify problems in managing captive populations in zoos (for example Kleiman *et al* 1991; Lindburg *et al* 1997; Stoinski *et al* 1997). Conclusions drawn from these studies have been included in the development of methods that provide zoo animals with adequate sensory input to exhibit a natural behavioural repertoire. In several cases, documented evidence from zoo welfare research that has managed to successfully improve captive primate welfare, have been compiled into husbandry guidelines for the management of the species in captivity (Wiese & Hutchins 1997).

1.3. WHAT IS CONSERVATION BIOLOGY?

The word 'conserve' means to prevent destruction or harm and 'conservation' is the process of conserving (Simpson & Weiner 1998). Conservation biology is a scientific discipline that aims to provide the information required to maintain biological diversity by preserving its natural state and its biological processes (Cowlishaw & Dunbar 2000). Hence, animal and plant communities are important along with the ecological and evolutionary processes that give rise to them (Soule & Wilcox 1980). The two mains goals of conservation biology are to determine human impacts on biological diversity and to develop practical solutions to prevent the extinction of species (Primack 1993).

Animal populations can decline naturally for a variety of reasons but the primary driving forces of this decline are the availability of food, the intensity of predation and the prevalence of disease (Cowlishaw & Dunbar 2000). In severe conditions, these environmental forces can lead to population extinctions; but of more concern are the extinctions caused by human impact. The man-made extinctions are caused either directly through habitat disturbance and hunting or indirectly through the introduction of exotic species (Primack 1993). Hence, even though extinction is a natural process, the mass extinctions that are currently wiping out entire taxa and some communities have been widely accepted as being caused by humans (Cowlishaw & Dunbar 2000).

In recent years, conservation of biodiversity has finally received its due attention from various groups, which include scientists, local and international government agencies, non-governmental organisations and the population as a whole (Cowlishaw & Dunbar 2000). Even so, with the global human, *Homo sapiens*, population on the increase, large areas of this biologically diverse planet are being cleared for human habitations and agriculture (Mittermeier 1997). This large-scale destruction of approximately 20.4 million hectares of tropical rainforest being deforested annually (World Resources Institute, 1990) along with other natural habitats, has left certain groups of species more prone to becoming extinct than others (Mittermeier 1997).

Biodiversity is conserved either by *in-situ* or *ex-situ* programmes, or both. *In-situ* or 'on-site' conservation includes all efforts made to conserve a species, taxa or community in its natural habitat. An example of *in-situ* conservation is the conservation of cotton-top tamarins (*Saguinus oedipus*) in their natural habitat in the Neo-tropical rainforests of North-western Columbia (Savage *et al* 1997). *Ex-situ* conservation or 'off-site' conservation includes conserving the species or taxa in zoos or conservation centres (Primack 1993). Species that are threatened by extinction are bred in captivity and later released into their natural habitat. For the purpose of breeding in captivity, either some individuals of the species are captured from the wild or individuals that are already present in zoos are included in the breeding programme. Once the animals have bred successfully in captivity, they are either reintroduced (release of animals into natural habitat where their historical range used to exist) or restocked (release of animals into their natural habitat to supplement existing wild populations of same species, Primack 1993). A good example of *ex situ* conservation is the conservation breeding and reintroduction programmes of the golden lion tamarin (*Leontopithecus rosalia*) in the Amazonian rainforests in Brazil (Kleiman *et al* 1986; Stoinski *et al* 1997; Kleiman & Mallinson 1998). During the 1980s, the free-ranging population of golden-lion tamarins consisted of less than 100 individuals (Kleiman & Mallinson 1998). By 1998, a conservation breeding programme involving American and European zoos reintroduced several groups from the captive stock increasing the numbers of the wild population. Monitoring of the reintroduced groups has also shown that captive-bred individual successfully reared young in the wild (Stoinski *et al* 1997).

1.3.1. Conserving primates in their natural habitats

Primates are the closest living relatives of humans and consist of approximately 250 species, which include prosimians, Old and New World monkeys and apes (Mittermeier 1997). By studying non-human primates, scientists have been able to learn more about human behaviour. However, the greatest threats to their survival are habitat changes made by the ever increasing human population and hunting (Mittermeier 1997; Fuentes & Wolfe 2002).

Primates are currently found in 92 countries around the world, with 90% of all primates being found in the tropical rainforests such as the Amazonian rainforest in South America (Mittermeier 1997). Rainforests rank high among the worlds most biologically diverse ecosystems (Mittermeier 1997; Cowlishaw & Dunbar 2000; Fuentes & Wolfe 2002). Primates play an important role in these rainforests for example the spider (*Ateles* spp.) and woolly monkey (*Lagothrix* spp.) species that occur in the Amazonian rainforest act as seed dispersers (Cowlishaw & Dunbar 2000).

In some conservation programmes, primates are used as a flagship species to help save the entire ecosystem (Savage *et al* 1997; Weber & Vedder 2001). Currently, several of these wild populations of primates are threatened by extinction due to habitat destruction and fragmentation, hunting for food and hunting for trade (Mittermeier 1997; Cowlishaw & Dunbar 2000; Fuentes & Wolfe 2002). For example, the 'Bari', the indigenous people of Venezuela, hunt the locally found primates for food and for necklaces that are made of monkey teeth (Fuentes & Wolfe 2002). These monkeys are also captured by the Bari as pets. In the Manu Biosphere Reserve, situated in South-eastern Peru, lives one of the world's most diverse primate communities (Fuentes & Wolfe 2002). Of all the species, the reserves indigenous people, the Matsigenke are known to prefer the spider monkey (*Ateles paniscus*) and the woolly monkey (*Lagothrix lagothricha*) as food. Due to these pressures, the World Conservation Union (IUCN) primate specialist group lists nearly half of the living species of primates as species of conservation concern (Mittermeier 1997). Today, one in every five species is already endangered or threatened, indicating that they could go extinct in the next few years (Cowlishaw & Dunbar 2000).

In order to understand the factors leading to the decrease in the numbers of these species, scientists have been studying them in their natural habitat, to document their distribution, home ranges, behaviour, ecology, and most importantly the impact of human population growth on these primate communities (for example Goodall 1971; Fossey 1983; Kleiman *et al* 1986; Weber 1987; Harcourt 1996; Savage *et al* 1997; Stoinski *et al* 1997; Zeeve & Porton 1997; Kleiman & Mallinson 1998). The mountain gorilla (*Gorilla gorilla beringei*) of the Virunga region, for example, is endangered and has been in the focus of long-term research, education and conservation efforts (Harcourt 1996). Continued poaching of gorillas and threats of further habitat losses from the Volcanoes National Park led to the formation of a consortium of conservation organisations to launch the Mountain Gorilla Project in 1979 (Weber & Vedder 2001). The conservation of gorillas specifically involves research in ecology and behaviour, ecotourism, anti-poaching squads and even conservation education (Weber & Vedder 2001). The long-term research in gorilla behaviour and their social organisations initiated by Dian Fossey and also the ecological research conducted by other scientists led to the development of one of most successful ecotourism programmes of the 1980s, centred on viewing the gorillas in their natural habitat (Weber & Vedder 2001). This programme not only raised public awareness and changed the attitude of the public towards the park, which spans over Rwanda, Democratic Republic of Congo and Uganda, but also funded conservation education projects, which employed local people (Weber & Vedder 2001).

In another example, the threats towards Malagasy prosimians and their natural habitat inspired zoo personnel, scientists and conservationists from all over the world to collaborate to initiate a long-term conservation action plan, which included breeding the threatened prosimians in captivity for future reintroductions. The programme also supported *in situ* conservation projects and conservation awareness (Zeeve & Porton 1997). The cotton-top tamarin is another such endangered species endemic to the rainforests of Columbia. In order to save this species from going extinct, an integrated approach was developed to conserve habitat and increase public awareness and action in local communities (Savage *et al* 1997).

1.3.2. Breeding primates in captivity and their reintroduction into their natural habitat

During the mid-20th century, zoos began to include research and conservation in their mandates. Heini Hediger (1964), the father of zoo-biology was the first to strongly emphasise the need to include research and conservation programmes in zoos in his books on wild animals in captivity. During the same period, Gerald Durrell (1960) also suggested the initiation of long-term breeding programmes in zoos to complement *in situ* conservation. By the early 1970s, wild animals were being bred in captivity and growing concern of the dwindling numbers of the species in the wild led to the reduction of acquisition of animals from their natural habitats (Wallis 1997). Several of the breeding programmes set up were for primate species from different parts of the world (Wiese & Hutchins 1997; for examples refer to Lindburg *et al* 1997; Savage *et al* 1997; Stoinski *et al* 1997; Zeeve & Porton 1997).

Conservation breeding is a strategy used to complement *in situ* conservation efforts to save species that are on the verge of going extinct (IUDZG/CBSG (IUCN/SSC) 1993). For the efficient management of breeding programmes of captive populations of primates, it is important to ensure that the populations are healthy, and to safeguard their long-term viability. Proper diets and veterinary care are as critical to a captive colony of primates as is demographic and genetic management (Wiese & Hutchins 1997). One of the goals of organised conservation breeding programmes is to maintain a genetically diverse and demographically stable, self-sustaining population of living organisms. For example, to address the problem of reducing numbers of free-ranging wild golden lion where tamarins (*Leontopithecus rosalia*), the National

Zoological Park and Smithsonian Institution initiated a long-term investigation on the reproduction, social behaviour and husbandry of this species in captivity (Kleiman *et al* 1986; Stoinski *et al* 1997; Kleiman & Mallinson 1998). Studies showed that these tamarins were being inappropriately fed and housed. Changes in the diet and social housing conditions resulted in a tremendous increase in golden lion tamarin numbers by the 1970s and 1980s (Kleiman *et al* 1991).

For the future of conservation of most species at risk from extinction, there is a requirement not only for the preservation and management of critical habitats but also for the development of scientifically-managed propagation programmes for captive animals by zoos (Kleiman *et al* 1986). While conservation breeding programmes can never be the ultimate solution to the conservation of primates, it is still the only option for a wide variety of species whose populations have become so small and fragmented that they cannot survive without human intervention (Hutchins *et al* 1995; Lofton 1995). However, through successful use of conservation breeding and reintroduction, scientific research, *in situ* conservation efforts and public education, professionally-managed zoos can play a significant role in primate conservation (Wiese & Hutchins 1997). For a successful conservation strategy, the involvement of a management plan and an educational strategy is a must. Basic and applied research is absolutely essential and the fields of psychology, physiology, behaviour, reproduction, genetics and animal welfare should be emphasised in zoo research for the development of scientifically-based recommendations and management (Kleiman *et al* 1986). For better success, zoos, local and international conservation organisations and the government should assemble their efforts to give rise to a coordinated conservation breeding programme, and this is true for any species in urgent need of conservation.

1.3.3. Conservation education

With the growing awareness for the need to conserve wild animal populations through *ex situ* and *in situ* programmes, individual zoos began to work to improve their primate exhibits in order to provide the zoo visiting public with information of the species on exhibit (Wallis 1997). Public education soon became important to the protection and maintenance of habitat as well as to the success of endangered species recovery efforts (Gold 1997). More than 120 million people visit American zoos recognised by the American Zoos and Aquaria Association (AZA) annually and the potential to use this to educate the visiting population on primate conservation was found to be unlimited (Wiese & Hutchins 1997). In America, the education programmes have become the primary focus of Species Survival Plans and Taxon Advisory Group (Aveling 1987). One of the key advantages of designing education programmes on primates is that they already enjoy great public appeal. The World Conservation Strategy produced jointly by the World Conservation Union (IUCN), the World Wide Fund for Nature (WWF) and the United Nations Environment Programme (UNEP) in 1980 attempted to catalogue the important tenets of environmental conservation, emphasising that environmental education is an essential part of this process (Aveling 1987). By the 1990s, all modern zoos strived to promote public awareness in wildlife conservation. The information provided to the visiting public was in the form of newsletters, graphs, exhibit labels and leaflets (Gold 1997).

Conservation education is defined as "any type of education that is designed to lead to an improvement in the management of natural resources" (Aveling 1987). Conservation education programmes have been designed to cater to different groups of people, and the methods used to educate the public are also very diverse. For example, in the Fort Wayne Childrens Zoo, in Indiana, an interactive education and conservation action programme called "Save the Primates" was used to assist primate conservation in the Mentawi Islands, Indonesia (Wiese & Hutchins 1997). Through this programme, school children in Indiana are exposed to the culture of the indigenous people of Mentawi and also informed about the region's five endemic species of primates. Through this education programme, these students could also exchange letters with Indonesian students and raise funds to promote the conservation of primates in Indonesia. With the help of various zoos and conservation organisations worldwide, a letter writing campaign was initiated which helped to halt conversion of Siberet Rainforest to palm-oil plantations in Indonesia, thus maintaining the natural habitat (Wiese & Hutchins 1997). Conservation education has also helped by sensitising local communities to primate conservation. In Madagascar, for example, in response to international concern for lemurs, the Fauna Interest Group was established (Zeeve & Porton 1997). The main objectives of this group were to protect lemurs through conservation breeding, conservation education and by providing ongoing training to Malagasy forest department staff. Another conservation education programme that has been very successful in increasing student awareness and interest in local conservation activities is the programme set up to prevent the cotton-top tamarin found in the Columbian rainforest from going extinct (Savage *et al* 1997). The programme also uses a three phase action plan (awareness, affinity and action) to promote the cotton-top tamarin as a "flag-ship species", also highlighting the importance of understanding culture, the conservation problem, and employing practical solutions in developing a conservation plan.

1.4. PRIMATES IN CAPTIVITY

The primary aim of the modern zoos housing primates has evolved from being purely for recreational purposes in the 1990s to promoting conservation of the species through breeding, release and public awareness (Mittermeier 1997). In order to achieve their conservation goals, zoos house primates in naturalistic exhibits that stimulate individuals to exhibit a natural behavioural repertoire. Species that are sympatric (species occurring in the same or overlapping geographical areas, Primack 1993) or those living in similar habitats are also housed together in 'mixed-species' exhibits to provide natural inter-specific interactions (Thomas & Maruska 1996). The biology and behaviour of primates in captivity are also monitored in many zoos in order to identify problems, in housing, health and breeding, if and when they occur (Wallis 1997).

In most zoos in North America, Europe and Australasia, advanced husbandry and management methods are used to house primates leading to modern exhibit design, which stimulate the animals to display a more natural behavioural repertoire. In fact, while primates housed in these zoos rarely exhibited abnormal behaviours (Skyner, *pers. comm.*), primates housed in Indian zoos displayed a wide variety of behavioural abnormalities (Mallapur & Choudhury 2003; Mallapur in press). These behavioural abnormalities are fairly similar in form and manner to the behaviours exhibited by primates housed in laboratories (Anderson & Chamove 1980; Chamove *et al* 1984; Anderson & Chamove 1985). Since the welfare of captive lion-tailed macaques housed in Indians zoos will be addressed in this thesis, it was thought appropriate to use evidence from laboratory-based primate studies to interpret these results.

1.4.1. Influence of enclosure design on the behaviour of captive primates

Animals are sensitive to their physical environment and this is critical to their welfare (Appleby & Waran 2000). The provision of appropriate space of adequate quality and quantity for all animals in captivity is a must (Buchanan-Smith *et al* 2004; Prescott & Buchanan-Smith 2004). A considerable number of studies are attempting to apply a biological approach to environmental design; even so, there are few well-coordinated projects on the effects of enclosure design on the welfare of captive animals (Appleby & Waran 2000). All species require species- or taxa-specific enclosure design. Primates, for example, require sufficient usable space – horizontally and vertically, and, most importantly, a complex environment that provides the necessary sensory inputs which would stimulate them to exhibit species-specific behavioural patterns (O'Neill *et al* 1991; Mallapur & Choudhury 2003; Buchanan-Smith *et al* 2004). Primates housed in unnaturally barren environments or small exhibits, are deprived of appropriate stimuli for the expression of a natural behavioural repertoire (Reinhardt *et al* 1996; Reinhardt 1997). Hence, it has been suggested that the provision of extra barren space does not significantly change behaviour of captive primates (Reinhardt *et al* 1996). It has been observed that animals housed in sub-optimal environments develop a wide range of abnormal behavioural patterns (for example Clarke *et al* 1982; Goerke *et al* 1987; O'Neill *et al* 1991). O'Niell *et al* (1991) compared the behaviour of laboratory-born juvenile rhesus macaques (*Macaca mulatta*) housed in the standard laboratory setting and then in a naturalistic environment. The juvenile macaques housed in the outdoor naturalistic enclosure exhibited higher levels of locomotion, exploration and lower levels of self-oral behaviour. Another study conducted on captive lemurs showed that individuals housed in smaller indoor enclosures were less active than those housed in larger outdoor enclosures (Macedonia 1987).

A study conducted on endangered tamarin species in captivity, showed that by designing large, naturalistic habitats that mimic aspects of the natural habitat, high reproductive success in the study animals was achieved (Snowdon 1991). The captive tamarin colonies were housed in an enclosure, which contained a complex design of aerial pathways made of ropes, boards and branches. This complex network helped to simulate an arboreal environment. Snowdon (1991) also suggested that the physical, social and cognitive skills acquired by the animals housed in this complex captive environment would prove useful if they were to be reintroduced into the wild.

Captive environments need to constantly be updated and improved. In their paper on the design of an enclosure for Sumatran orang-utans (*Pongo pygmaeus abelii*), Mallinson *et al* (1994) documented how zoo environments take into consideration the behavioural requirements of captive orang-utans. At that time, the enclosure at Jersey Zoo included two spacious landscaped moated islands of approximately 1500 m^2 and 870 m^2. The enclosure consisted of substantial climbing structures, platforms, netting and a series of ropes, which provided the animals with an aerial pathway simulating the rainforest canopy of their natural habitat (Mallinson *et al* 1994). A study on Hanuman langurs (*Presbytis entellus*) showed that by shifting the group to a naturalistic enclosure, feeding and locomotory behaviours increased whereas sleeping and aggression decreased in the study animals (Little & Sommer 2002). The new enclosure also gave the langurs the opportunity to maintain a distance from the visitors.

Another method of choosing the appropriate enclosure design for a given captive animal or group is to allow them to choose. This method is known as preference testing (Fraser & Matthews 2000). For example, in a study conducted on two groups of captive common marmosets (*Callithrix jacchus*), animals were given a choice of the size and position of nest boxes that were newly introduced into their enclosures

(Hosey *et al* 1999). The study showed that the animals had a strong positional preference, and one group also preferred the high nest box.

Scientists emphasise that no single factor should be used to determine the size of enclosures for captive primates (Buchanan-Smith *et al* 2004; Prescott & Buchanan-Smith 2004). Instead, a group a factors which include the individual's morphometric, physiological, ecological, social and behavioural characteristics should be used to determine the adequate enclosure sizes for captive primates (Buchanan-Smith *et al* 2004).

1.4.2. Influence of early rearing history on the behaviour of captive primates

Rearing history also influences the behavioural repertoire of zoo primates (Mootnick & Baker 1994; Mallapur & Choudhury 2003; Mallapur in press). There is a high incidence of abnormal behaviour in captive primates with a history of social deprivation (for example Anderson & Chamove 1980; Chamove *et al* 1984; Anderson & Chamove 1985; Mootnick & Baker 1994; Mallapur & Choudhury 2003). Self-mutilatory behaviours (when an animal directs threats towards a part of its own body, Chamove *et al* 1984), for example, have been observed in singly-housed animals and in animals with a history of social deprivation. A study on 24 laboratory-born stump-tailed macaques (*Macaca arctoides*) that had been separated from their mothers during the first week of life and reared alone stated that this procedure led to the appearance of self-aggression by three months of age in the juveniles (Chamove *et al* 1984). In their review on self-aggression, Chamove and Anderson (1981) revealed that most of the reports of self-aggression in captive primates concerned singly-housed animals. These abnormal traits are not usually seen in free-ranging animals or in animals in captivity that are housed in groups (Erwin & Deni 1979). It has been suggested that self-mutilatory behaviour or self-aggression is a form of redirected social aggression exhibited by individuals in the absence of social targets (Anderson & Chamove 1980; Chamove *et al* 1984). Self-mutilatory behaviour, like other forms of abnormal behaviour, also probably increases sensory inputs in poor environments (Chamove *et al* 1984; Anderson & Chamove 1985). A study of breeding behaviour in mangabeys (*Cercocebus* spp.) showed that socially-deprived individuals exhibited abnormal behaviour and did not breed even when they where housed in pairs (Mitchell *et al* 1987).

Another study on captive pig-tailed macaques (*Macaca nemestrina*) showed that infants that were separated from their mothers but had access to peers, developed abnormal behaviours (Worlein & Sackett 1997). Several studies have also indicated that captive primates that were closely associated with humans at a young age exhibited abnormal behaviour patterns (Mootnick & Baker 1994; Mallapur & Choudhury 2003; Mallapur in press). For example, captive macaques (*Macaca* spp.) that were confiscated from private owners exhibited higher levels of self-aggression and stereotypic pacing than individuals born at the zoo or those that were caught from the wild (Mallapur & Choudhury 2003; Mallapur in press).

1.4.3. Influence of group composition and size on the behaviour of captive primates

Free-ranging primates are known to live in groups that vary in size and composition (Gupta 2001). Some species, like lorises, live solitarily while others, like the gibbons, live in pairs. Baboons, langurs and macaques, live in large groups. Baboon groups consist of only one male with several females, whereas langur and macaque groups consist of several males and several females (Gupta 2001). The modern zoo takes care to ensure that primates are housed in their species-specific group compositions.

Primates are dependent upon their family groups at birth, since they require considerable care during infancy (Erwin & Deni 1979). Hence, in the wild, primates' lives are social from birth to adulthood. Housing animals singly or in a group composition that is inappropriate for the species could result in a reduction in exploratory and social behaviours exhibited (for example Kiley-Worthington 1977; Rendall & Taylor 1991; Buchanan-Smith 1996, 1997). It also stimulates the exhibition of abnormalities such as self-mutilatory behaviour, self-clasping, masturbation, re-ingestion, regurgitation, coprophagy, stereotypic pacing and an inability to breed (Erwin & Deni 1979; Rendall & Taylor 1991; Reinhardt 1997). For example, a study on a captive group of Japanese macaques (*Macaca fuscata*), consisting of one male and three females, observed the dominant female participating in most of the copulations with the male and disrupting copulations between the male and other females (Rendall & Taylor 1991). The lowest ranking female was observed to exhibit auto-erotic stimulation and homosexual behaviours. The authors suggested a complex multi-male, multi-female grouping for this species to avoid the monopolisation of the group by the dominant female.

In a review on social housing of previously single-caged macaques Reinhardt *et al* (1995) suggested that social housing of singly-housed macaques improves their behavioural health by providing them with an adequate environment to exhibit social interactions. When adult singly-housed rhesus macaques were paired with infant rhesus macaques, the proportion of abnormal behaviour exhibited decreased (Reinhardt *et al* 1987). In another study conducted on captive primates in Indian zoos, housing macaques singly or in pairs, was found to be inappropriate since macaque pairs and singly-housed individuals exhibited significantly higher levels of abnormal behaviour than did group-housed animals (Mallapur in press).

1.4.4. Influence of method and time of feeding on the behaviour of captive primates

While free-ranging primates spend a significant proportion of their time foraging and gathering food, zoo primates often lack these opportunities, as food is made available in such a manner that little or no foraging or gathering is required to retrieve it (Marriner & Drickamer 1994; Bloomsmith & Lambeth 1995). Hence, primates in zoos spend less time feeding and foraging than their wild counterparts. Several forms of abnormal behaviours in animals have been found to be related to methods of feeding and the time of feeding (Bloomsmith *et al* 1988; Marriner & Drickamer 1994; Bloomsmith & Lambeth 1995; Carlstead 1998; Lukas *et al* 1999; Waitt & Buchanan-Smith 2001). In a study on the influence of feeding time on the behaviour of captive chimpanzees (*Pan troglodytes*), the behaviour of 30 chimpanzees was recorded before and after feeding time (Bloomsmith & Lambeth 1995). The study showed that unpredictable feeding schedules led to an increase in natural behaviours such as active and foraging behaviours. Waitt and Buchanan-Smith (2001), however, suggest that feeding schedules should be changed only after careful considerable, since zoo primates tend to exhibit abnormal behaviour just before feeding time in anticipation of being fed. In their study on the influence of feeding schedules on the behaviour of stump-tailed macaques in captivity, Waitt and Buchanan-Smith (2001) showed that the feeding routine affected the behavioural repertoire of the study animals, with delays in feeding having a considerable negative impact on behaviours exhibited. Their study showed that animals that had to wait for their food exhibited significantly higher levels of self-directed behaviour, inactivity, vocalisation and abnormal behaviours for longer.

Species- or taxa-specific differences in food acquisition techniques could probably influence the welfare of captive primates. Marriner and Drickamer (1994), in their study on abnormal behaviour in captive primates, for example, observed omnivores (primates having a diet of both plant and animal matter) to exhibit higher levels of stereotypy than folivores (primates having a diet of mostly plant matter and possibly some insects). According to their study, omnivores spend more time foraging in the wild. In the absence of insects and dietary diversity, the time spent foraging by omnivores in captivity could be as low as that of the folivores which probably suggests that they spend more time exhibiting abnormal behaviours (Marriner & Drickamer 1994). Their higher cognitive capacities could also render gibbons (*Hylobates* spp.) and macaques more prone to the adverse influences of captive environments than (refer to Milton 1988 for differences between frugivorous, folivorous and omnivorous primates) langurs. Similar differences were found between the captive omnivorous and folivorous primates housed in Indian zoos (Mallapur & Choudhury 2003).

Previous studies on non-human primates have shown that diets and especially complex foraging strategies related to the procurement of food are associated with relative brain size (Milton 1988). On comparing brains of frugivorous and omnivorous primates with those of folivores, it was shown that the former tended to have larger brain sizes (Clutton-Brock & Harvey 1980 as referred to in Milton 1988).

On readdressing the time and energy spent in foraging, scientist found that omnivores expended more energy during foraging bouts than folivores (Milton 1988). This was because while omnivorous primates are required to first locate, then pursue and capture their prey (Milton 1988), folivorous primates do not have to devote any time and energy in pursuit since their food items (for example leaves) are sessile (Westoby 1974 as referred to in Milton 1988).

Primates are known to possess "nutritional wisdom", which enables them to choose their own nutritionally balanced diet from a broad array of food items given to them by the zoo staff (Oftedal & Allen 1996). Most zoos present food items to primates in a chopped form, in order to increase the variety of food items eaten per individual (Smith *et al* 1989). However Smith *et al* (1989), demonstrated in their study on food preparation for lion-tailed macaques in captivity that the mean dietary diversity increased with presentation of whole foods, as did the time spent feeding and total amount of food consumed per individual.

Nutritional factors may also lead to the sustained performance of certain abnormal behaviours such as regurgitation and reingestion (Lukas 1999). In her study, Lukas (1999) conducted a comparative analysis of ruminatory behaviour in humans and stereotypic behaviour in captive, domestic animals. The study revealed several nutritional and motivational factors, which could lead to the exhibition of regurgitation and reingestion.

1.4.5. Influence of the zoo visiting public

A considerable amount of research has been conducted on the influence of visitors presence on the behaviour of captive animals, most of which were conducted on primates (Chamove *et al* 1988; Hosey & Druck 1987; Mitchell *et al* 1991; Venugopal & Sha 1993; Cook & Hosey 1995; Glatson *et al* 1984; Birke 2002; Blaney & Wells 2004; Skyner *et al* 2004). Visitors have been found to serve as a source of stress for zoo primates (for example Chamove *et al* 1988; Mitchell *et al* 1991; Venugopal & Sha 1993). For example, a comprehensive study was conducted on 15 species of primates of varying sizes and arboreality to study the influence of visitor presence on their behaviour (Chamove *et al* 1988). In the first part of the study, Chamove *et al* (1988) found that levels of agonistic behaviour increased in three species of primates (cotton-top tamarins, *Saguinus oedipus*, Diana monkeys, *Cercopithecus diana* and ring-tailed lemurs, *Lemur catta*) when visitors were at the viewing window. A significant decrease in other behaviours, such as grooming and affiliative behaviours was also associated with visitor presence. The study also showed that individuals from a group of mandrills, *Mandrillus sphinx* were more aggressive when visitor were present, exhibiting higher levels of stereotyped behaviour (Chamove *et al* 1988). In another study on 10 captive golden-bellied mangabeys (*Cercocebus galeritus chrysogaster*), the study animals were observed to direct the greatest number of their threats to zoo visitors in comparison to zoo staff and the observer (Mitchell *et al* 1991). The authors suggested that the zoo visitors were treated like 'interlopers' by the captive mangabeys, while the zoo staff were treated like familiar conspecifics and the observer like a familiar neighbour.

Visitor presence has been found to influence the behaviour of primates in captivity (Hosey & Druck 1987; Cook & Hosey 1995; Birke 2002). The presence of active audiences (zoo visitors who try to interact with the animals) tends to produce a change in behaviour in the animals (Hosey 2000). A study on the influence of visitor presence on captive primates showed that primates exhibited higher levels of locomotory activity during the presence of active audiences. The animals were also observed to spend more time at the front of their exhibits (Hosey & Druck 1987). From this behaviour, Hosey and Druck (1987) concluded that captive primates do not completely habituate to the presence of the public, nor do they ignore them. Even so, the chronic exposure of captive primates to the zoo visiting public could reduce the stressful influence in some species (Hosey 2000). Hosey (2000) also suggested that some of these human-animal interactions could also prove enriching for the animal, especially those in which they are fed by the zoo visiting public. For example, in a study conducted on 24 captive chimpanzees at Chester Zoo, it was found that the behaviour of the zoo visiting public was influenced by that of the chimpanzees (Cook & Hosey 1995). When the animals begged for food the visitors offered them some.

Approximately, 25% of the interactions that were initiated by the visitors resulted with the chimpanzees being given some food by the public (Cook & Hosey 1995).
In some cases, teasing of zoo primates by visitors has also influenced the behaviour of these animals (Venugopal & Sha 1993). Visitor noise can influence the behaviour of captive primates, as shown in a study conducted on the effect of zoo visitors on the behaviour of captive orang-utans (Birke 2002). The presence of visitors could also influence the proportions of abnormal behaviour exhibited by captive primates. For example, a study on the effect of visitors on the self-aggressive behaviour of a male pileated gibbon (*Hylobates pileatus*), showed that the proportions of self-aggression behaviour exhibited by the gibbon increased with the increase in visitor numbers (Skyner *et al* 2004).

1.5. ANIMAL WELFARE

1.5.1. What is animal welfare?

The term 'animal welfare' did not arise in science to express a scientific concept but did in society to express ethical concerns regarding the treatment of animals (Duncan & Fraser 2000). Hence scientists have found it a problem to define 'animal welfare' as they do in other technical terms in science. Even so, for the purpose of this thesis, 'animal welfare' will be defined as 'the state of an animal as regards its attempt to cope with its environment' (Broom 1986). The welfare of an animal is also related to its ability to display a full repertoire of natural behaviours in its captive environment (Kiley-Worthington 1977). Its failure to doing so would suggest that its captive environment is sub-optimal (Brambell Committee 1965). Psychological well-being, a term more commonly used by psychologists is defined as the 'way an animal feels about its state' (Broom 1986). In Indian zoos where the provisions made for primates in captivity are very basic and most times sub-optimal, a biological function based approach was used to define welfare.

For wild animals in captivity, the absence of appropriate environmental stimuli could lead to the disruption of their physical and physiological functions (Fraser & Broom

1997). When these normal biological processes are disrupted in an artificial environment such as in a zoo, the animal is said to be under stress. Stress has been defined as 'the environmental effect on an individual, which over-taxes its control systems and reduces its fitness' (Fraser & Broom 1997) and stressors are the 'environmental factors, which lead to this stress' (Selye 1950). The captive animals' responses to stressors are known as the 'stress response'.

1.5.2. Why assess 'animal welfare' in zoo animals?

Ethically, it is essential to assess the welfare of zoo animals to prevent their welfare from being compromised and to minimise stress. Also, most of the species housed in a zoo are those that are on the brink of extinction (Primack 1993). The goals of a zoo are to breed these endangered species in order to reintroduce them into their natural habitat and to educate the zoo visiting public (Smith 2004). Hence, it is imperative that zoos maximise the reproductive output of the species they house and provide the appropriate environmental stimuli to motivate them to exhibit a natural behavioural repertoire. Stress could influence an animal's ability to breed and also lead to the exhibition of abnormal behaviours (Carlstead 1996). Animals exhibiting abnormal behaviours also constitute poor exhibits and could convey an inappropriate impression to visitors (Mallapur in press).

1.5.3. How to measure 'animal welfare'?

There are three approaches to assessing animal welfare (Duncan & Fraser 2000);

(I) 'Feeling-based' approaches - measured through an animal's preferences and motivations, and through behavioural and physiological indicators of emotional states.

Welfare, in this case, can be reduced by negative subjective states such as pain, fear, frustration, hunger or thirst and can be improved by positive states such as comfort, contentment, and the pleasure of certain types of social interaction.

(II) 'Function-based' approaches - measured by monitoring health, longevity, reproductive success, and disturbances to behaviour and physiology.

(III) 'Nature' of animals based approach – measured through an individual's ability to perform a full natural behavioural repertoire.

Some of the factors that have been used as welfare indicators are mortality rates, reproductive success, proportions of abnormal behaviour exhibited, severity of injuries, degrees of immuno-suppression and level of disease incidences (Fraser & Broom 1997). Reduced fitness of an individual can be used to measure the detrimental influence of adverse environmental conditions on an animal.

Health and disease can also be used to assess welfare in animals, but careful observation is required and a broad range of indicators such as changes in physiology, behaviour and production, need to be considered (Hughes & Curtis 2000). The use of health as a welfare indicator depends on the observer's capability to draw inferences from subjective feelings such as pain, discomfort and distress. A good understanding of epidemiology could also guide an observer while using symptoms, lesions and behavioural responses as cues to clarify the relationship between disease and welfare.

The use of behaviour as an indicator of welfare in captive animals is regarded as a highly controversial topic (Mason 1991). Even so, behaviour, being the most easily observable measure of welfare, is used widely to assess welfare of captive animals (for example Chamove *et al* 1984; Mason 1991; Fritz *et al* 1992; Marriner & Drickamer 1994; Mootnick & Baker 1994; Worlein & Sackett 1997; Lukas 1999). Mench and Mason (2000) stress that the knowledge of species-typical behaviour and of the behaviour of individuals and their social groups is a prerequisite for using behaviour to assess welfare, because the exhibition of a normal behavioural repertoire varies with any given situation, the species and on the strain on the animal. Behaviour provides information on an animal's needs, preferences and internal states. Changes in the frequencies of suppression or an out of context exhibition of behaviour can provide clues about welfare problems. The use of abnormal behaviour as an indicator of poor welfare is complex and though it is relevant to the study of animal welfare, care should be taken to have a sound understanding of the development, causes and consequences of abnormal behavioural patterns before conducting the study (Mason 1991; Mench & Mason 2000; Mason & Latham 2004).

Physiological stress responses have also been used to measure poor welfare (Terlouw *et al* 2000). The most commonly measurable stress responses are (I) plasma gluco-corticosteroids, which reflect the activity of the hypothalamo-pituitary-adrenal axis and (ii) plasma adrenaline/noradrenaline and heart rate, which reflect the activity of the sympatho-adrenomedullary system. Animal welfare can also be measured by running preference and motivation tests (Fraser & Matthews 2000). These tests provide useful information on the reaction of animals to handling and housing and to other environmental features. It has been cautioned in literature that an animal's preferences that are revealed by the preference tests often identify environmental factors that will promote their welfare, and that this obvious link might break down if the tests are outside the individual's sensory and cognitive capacity (Fraser & Matthews 2000).

Despite there being an array of methods to assess the welfare of captive animals, in order to assess the welfare of captive animals in zoos, it is usually the case that a non-intrusive and hands-off technique needs to be used. This includes measures of behaviour, health and reproductive fitness that can be used to indicate when an individual's welfare has been compromised.

1.5.4. Methods of improving primate welfare

A large number of environmental variables collectively contribute to the welfare of captive primates (Maple 1979). Some of these variables can be put together in one group to form the elements of the physical environment. An improvement made to captive environments in order to improve the welfare of captive animals and to provide them with the right environment to exhibit species-specific behaviour patterns is called "environmental enrichment" (Newberry 1995). However, the types of enrichment provided to wild animals housed in zoos should be chosen carefully, in order to provide only those forms of enrichment that stimulate the captive animals to exhibit a full natural behavioural repertoire (Rabin 2003).

1.5.4.1. Redesigning enclosure spaces and provision of structural enrichment

Captive animals need to be provided with an artificial environment that mimics their natural habitat in order to stimulate them to exhibit the appropriate species-specific behaviours (Maple & Perkins 1996). Providing the captive animals with the appropriate enclosure furnishings can create such an environment. In order to improve zoo primate welfare, techniques must target issues such as the designing of complex, naturalistic enclosures that house animals in species-specific groups (Newberry 1995). Renovating and redesigning enclosures is the easiest and most common method of improving zoo environments for primates. This is done either by providing animals with new structural features in the existing enclosure (for example Estep & Baker 1991; Zucker *et al* 1991; Kessel & Brent 1996), or by moving all individuals into a new enclosure (for example Clarke *et al* 1982; Goerke *et al* 1987; O'Neill *et al* 1991; Little & Sommer 2002). The provision of structural features such as a temporary cover to a group of stump-tailed macaques, for example, could reduce contact aggression and the ability of the dominant male to monopolise all copulations (Estep & Baker 1991). In some of the cases where animals are transferred to more complex enclosures, previously-exhibited abnormal behaviours are observed to reduce (Clarke *et al* 1982; O'Neill *et al* 1991). Enclosures that provide their animals with access to the vertical dimension particularly provide opportunities, especially for arboreal species, to exhibit natural behaviours (Kessel & Brent 1996; Neveu & Deputte 1996; Malone 1998; Hebert & Bard 2000). More often than not, primates housed in enclosures with access to the vertical dimension are found to favour higher elevations rather than the ground level (Hebert & Bard 2000). Several other forms of enclosure features, such as sleeping platforms (*pers. obs.*) and suitable substrate (Ludes & Anderson 1996; Ludes-Faulab & Anderson 1999) have also been provided and found to benefit captive primates. Provision of deep litters composed of organic matter such as woodchips, peat and wood wool, for example, were found to have a positive influence on the behaviour of captive white-faced capuchins (Ludes & Anderson 1996; Ludes-Faulab & Anderson 1999).

1.5.4.2. Feeding enrichment

Several zoos have changed diets, method of feeding or even feeding time to improve the welfare of primates in their facilities. Abnormal behaviour exhibited in anticipation of being fed could be reduced by making the feeding time unpredictable (Bloomsmith & Lambeth 1995), though delaying the feeding time has sometimes increased abnormal behaviour because animals have to wait longer to be fed (Waitt & Buchanan-Smith 2001). Several methods have been used to present food differently to captive primates (Smith *et al* 1989; Buchanan-Smith 1995; Reinhardt & Robert 1996; Zimmerman & Feistner 1996). These include food scattering in deep litter (Ludes & Anderson 1996; Ludes-Faulab & Anderson 1999), food in hanging baskets (Zimmerman & Feistner 1996), food in bamboo pipes (Steen 1995), food on the roof of the enclosure (Reinhardt 1993; Buchanan-Smith 1995) and in puzzle feeders (Reinhardt 1993; Steen 1995; Reinhardt & Robert 1996). In most cases, changing the food presentation had a positive influence on behaviour, such as an increase in foraging and gathering behaviour (for example Smith *et al* 1989; Reinhardt 1993; Buchanan-Smith 1995; Zimmerman & Feistner 1996; Vick *et al* 2000). In a study on captive groups of barbary (*Macaca sylvanus*) and stump-tailed macaques (*Macaca arctoides*), replica fruits were distributed as foraging devices in order to evaluate their potential as enrichment objects. Both groups manipulated the replica fruits most when they functioned as a foraging device (Vick *et al* 2000). Giving primates whole vegetables and fruits increases diversity in the food eaten; food can also be chopped in pieces before feeding the animals (Smith *et al* 1989).

1.5.4.3. Social enrichment

Introducing new individuals to singly-housed primates (eg rhesus macaques) has often been found to reduce levels of abnormal behaviour such as stereotypy exhibited by the latter (Reinhardt *et al* 1987, 1995). Reinhardt *et al* (1995) found that macaques that were previously housed singly have successfully formed compatible pairs when introduced to other singly-housed individuals. When weaned rhesus macaque infants were introduced to singly-housed adult rhesus macaques, the infant-adult pairs were found to be compatible in 90% of the cases. When the singly-housed macaques were paired, the proportion of stereotypical behaviour exhibited by them reduced. Reinhardt *et al* (1995) explained how pair-housing of previously singly-housed macaques improves welfare by providing social contact and social interactions. Some studies suggest that group encounters provide a positive influence on behaviour as group encounters typically occur in the wild (Zinner *et al* 2001).

The administration of different forms of enrichment, helps to create novel environment, which stimulates captive primates to display a natural behavioural repertoire (for example Smith *et al* 1989; Zimmerman & Feistner 1996). Providing primates in zoos with a choice of enclosure furnishings has also proved to stimulate these animals into exhibiting species-specific behaviours (Hosey *et al* 1999). Providing choice and preference-testing of captive animals are however advanced methods of behaviour enhancement and are mostly used when the animals have already been provided with their basic requirements. In Indian zoos however, a considerable proportion of the captive primate population is not provided with the five basic freedoms, which include freedom from hunger and thirst, fear and distress, discomfort, pain, injury and disease and the ability to display natural behaviours (Fraser & Broom 1977).

1.6. CONSERVING LION-TAILED MACAQUES

1.6.1. Biology and behaviour

Extensive studies have been carried out on free-ranging lion-tailed macaques in the Western Ghats as well as on individuals in the American and European captive populations (Kumar 1987; Kaumanns *et al* 2001; Lindburg 2001; Raghavan 2001). Like other macaques, the lion-tailed macaques live in large groups ranging from eight to 40 with approximately 18 animals, on an average, in a troop (Kumar 1995, 1997;

Raghavan 2001). Within these groups, the number of adult males varies from one to three and adult females from five to eight (Kumar 1997). Lion-tailed macaque males are also known to disperse from their natal troops and form other troops in which they reside (Kumar *et al* 2001). They are primarily frugivorous (feeding on fruit) but their diet also includes a wide variety of fauna (Green & Minkowski 1977; Kumar 1987). Lion-tailed macaques are diurnally active, beginning their search for food trees at dawn and ending at dusk, but stopping to rest at noon (Umapathy & Kumar 2000a). The time of activity and its duration varies with season.

The age of female lion-tailed macaques at first birth is about 6 years (captivity 3.5-4.9 years; Lindburg *et al* 1989; Lindburg 2001) with a birth interval of 2.5 years (Kumar 1987) in the wild and approximately 1.5 years in captivity (Lindburg *et al* 1989). Free-ranging females stop breeding by the age of 18 years. Kumar (1987) recorded high infant and juvenile survival rates of 0.87/year and 0.90/year respectively in the wild. The survival rate for adults was 0.95/individual/year (Kumar 1987). Births are aseasonal, both in captivity and in the wild, occurring during nine months of the year, but with a small peak in June (Kumar 1987; Lindburg *et al* 1989). Mean birth rates were 0.28/female/year in the wild and 0.35/female/year in captivity. Birth rate and the overall growth rate of lion-tailed macaque groups have been found to decrease with increase in group size (Kumar 1995). The number of females in the group also influences the birth rate.

The reproductive behaviour of lion-tailed macaques is characterised by a relatively high female/male ratio, highly synchronous sexual cycles and harassment of the sexually-interacting male and female by other females with sexual swelling (Kumar 1987; Kumara *et al* 2000). Captive females in the swelling phase of their menstrual cycles were observed to exhibit proceptive calling during copulation (Lindburg 1990), particularly when non-group males were in the visibility range of the calling females. The biology and behaviour of lion-tailed macaques in the wild and in captivity have been well-documented and this information can be used very effectively to establish a breeding programme for the species in Indian zoos.

However, the welfare status of individual animals in the Indian captive lion-tailed macaque population is unknown. There is a dearth of information on the environment in which these individuals are currently housed and the factors influencing their welfare and ability to breed. The current study not only intends to target these issues but also will train animal keepers to be able to study animals, identify individuals and record reproductive behaviour such as sexual swelling which was observed in most of the females.

1.6.2. Conserving the lion-tailed macaque in its natural habitat

The lion-tailed macaque is an endangered species (Nameer *et al* 2001), endemic to the tropical rainforests of the Western Ghats of southern India (Green & Minkowski 1977; Lacy *et al* 1996; Singh *et al* 1997). It has been estimated that 3000 to 4000 lion-tailed macaques survive in 27 fragments or patches of its remaining habitat, which spans over three southern Indian states of Kerala, Karnataka and Tamil Nadu (Kumar 1987; Anonymous 1993; Lacy *et al* 1996).

Over the last century, vast areas of rainforest were cleared for coffee, tea, rubber and teak plantations and most of the remaining area was selectively logged (Kumar 1987; Karanth 1992). These operations fragmented the remaining forest and also brought about large-scale human settlement as work force. The present area of the rainforest that harbours the lion-tailed macaque is estimated to be about 5,000 km^2. Of this, only two areas, the Ashambu Hills and the Silent Valley – New Amarambalam forests that have substantial extent of contiguous rainforest (more than 400 km^2) to support populations of about 400 animals each. In other areas, the habitat has been severely fragmented into isolated patches of a few hectares to less than 100 km^2. Approximately 60% of the population was considered to be confined to small patches of less than 50 km^2. Over the recent years, concern about the rapidly depleting forest has reduced forestry operations in these forests in the three states (Kumar 1987).

Despite its relatively large free-ranging population, factors such as habitat fragmentation, inbreeding depression and its vulnerability to stochastic and human –

related events renders the lion-tailed macaque under threat of going extinct (Kumar 1995). After conducting an extensive study on the ecology and population dynamics of this species, Kumar (1987) explained how the lion-tailed macaque, being highly adapted to the stable rainforest habitat and having a low population growth rate and birth rate, does not have the capability to recover demographically from population perturbations due to natural or human related causes.

Changes in activity pattern and feeding ecology are the first set of alterations in the behaviour and ecology of the species caused by its interaction with its fragmenting habitat. The species final response to its fragmenting habitat is through demographic changes, which leads to its decline and eventually to its extinction. The influence of habitat fragmentation on free ranging lion-tailed macaque populations has been systematically studied over the last few years (Ramachandran & Joseph 2000; Singh *et al* 2000; Umapathy & Kumar 2000a, b; Kumara *et al* 2000). A study (Umapathy & Kumar 2000b) conducted in the rainforest fragments of the Anaimalai Hills on the lion-tailed macaques recorded a reduction in the time spent in feeding and an increase in movement across smaller more degraded patches. This study also documented a reduced birth rate and proportion of immatures in lion-tailed macaque groups with a decrease in size of the habitat fragment, which Umapathy and Kumar (2000b) suggested could be due to a decline in the proportion of invertebrates in the diet. Umapathy and Kumar (2000a) also discussed the males' inability to disperse from its natal group in smaller fragments. This could give rise to inbreeding suppression and also explain the variability in population size and sex ratio with fragment size. Other factors such as the presence of adequate food resources also affect the demography of lion-tailed macaque populations across the Western Ghats. For the survival of this species in the wild, Ramachandran and Joseph (2000) have emphasised the importance of conserving the *Cullenia* and *Palaquium* dominant rainforest species as the lion-tailed macaques heavily depend on these for food.

Though widely studied, the lion-tailed macaques' future remains precarious. As of today, most of its habitat is degraded and fragmented (Kumara *et al* 2000). Some forest fragments, which contain only one troop, have been isolated for several decades. Most of these fragments are situated in plantations and estates that are privately owned and there is no canopy continuity between adjacent patches. Habitat exploitation has still not been stopped in certain areas (Singh *et al* 2000). The growing concern for this species has resulted in an international conference on the lion-tailed macaques, and small population biology and tools recovery workshops, the latter jointly conducted by Conservation Breeding Specialist Group (CBSG) and Zoo Outreach Organisation (Kumar 1990; Anonymous 1993, 1996; Gledhill & Walker 1996; Lacy *et al* 1996). Through these conferences and workshops it was concluded that, to ensure the conservation of this macaque, effective management practices, both *in-situ* and *ex-situ*, are required.

1.6.3. Lion-tailed macaques in zoos

Breeding lion-tailed macaques in captivity for conservation purposes is not an easy task. However, a case study shows that the lion-tailed macaque population in US zoos doubled in size in a decade after the import of lion-tailed macaques from India was stopped voluntarily by American and European zoos due to a growing concern of their dwindling numbers in the wild (Lindburg *et al* 1997). This dramatic increase in the captive numbers arose from the intensified effort and improved management techniques in zoos (Lindburg & Gledhill 1992). Zoo management plans were initially driven by genetic requirements (Lindburg *et al* 1997), with the highest priority given to individuals having bred the least.

A stable core of females resided permanently in zoos participating in the breeding programme while the males were rotated between zoos emulating the natural migratory pattern of this species in its natural habitat. The process of moving the males across zoos was named the "MM" system. The female designated for breeding in a given year was temporarily separated from the breeding group for a short-term pairing with the genetically-selected sire. The females were not shifted because the study found that females did not fare well when transferred between institutions, particularly when integration into an established colony was attempted. In addition, Lindburg *et al* (1997) also explain how the study considered the welfare of this highly social primate by monitoring social interdependency and stability, rearing environments and kinship relationships. Individuals were always housed in specific social groupings and were only isolated for veterinary care. To promote social stability, some males were also housed within exhibit groups with the females and their offspring. These males were vasectomised to avoid unwanted pregnancies; this also allowed the full expression of sexual behaviour to occur. Some institutions housed surplus individuals for educational purposes, while others housed all-male troops.

In the European population of lion-tailed macaques, though numbers in captivity have doubled over the last ten years, serious problems are still being faced (Kaumanns *et al* 2001). About 25 to 30% of the adult females have not bred and the reason for this is not known. Kaumanns *et al* (2001) explain how the conditions under which the lion-tailed macaque populations are maintained in European zoos do not allow species-specific demographic and social patterns to be realised. This could be one of the reasons why the American captive population was regarded successful in breeding while the European one was not.

Another major problem influencing the reproductive success of the European captive population could be with regard to health and welfare-related issues. A high incidence of ovarian dysfunction and endocrine disorders in females older than 15 years of age (Heistermann *et al* 2001) and high infant mortality rates has been documented in this population (Kaumanns & Rohrhuber 1995). The reasons for these health problems, however, are unknown.

Captive individuals in the European population also exhibit a wide range of behavioural disturbances, which indicates that they have not been able to cope with their captive surroundings. Almost all groups observed had some individuals that displayed self-directed abnormal behaviours such as hair-plucking, eye-poking, saluting and also stereotypic pacing (see Tennemann 1992, as referred to in Kaumanns *et al* 2001).

In their paper on European lion-tailed macaque populations, Kaumanns *et al* (2001), admit that they do not know the lion-tailed macaque well enough to successfully breed them in captivity. Hence, reproductive success is not predictable enough and cannot be influenced systematically. Kaumanns *et al* (2001) questioned the low level of locomotive behaviour and general arousal exhibited by the individuals in the European zoo population. General arousal was found to increase and group cohesion was found to improve when group encounters were experimentally induced (Zinner *et al* 2001). Proportions of aggressive and social behaviours also increased. However, significant levels of intragroup aggression are usually absent in groups that are behaviourally stable (Lindburg 2001).

Apart from social interactions, studies on the heterozygosity and reproductive physiology have also been conducted on captive lion-tailed macaque populations. A preliminary electrophoretic analysis conducted on captive lion-tailed macaques suggested that the average level of heterozygosity for this species was comparable to other macaques e.g. *M. mulatta* and *M. nemestrina* (Jolly & King 1985). Other than pedigree determination studies conducted by Morin and Ryder (1991), no other genetic study has been conducted on wild or captive lion-tailed macaques. Studies to measure the faecal steroid metabolites in the lion-tailed macaque have also been conducted to provide initial information on ovarian cycle characteristics in breeding and non-breeding females (Heistermann *et al* 2001). Long term studies on reproductive physiology and behaviour were conducted at the Centre of Reproduction of Endangered Species at San Diego Zoo (Lindburg 2001). Reproductive physiology and behaviour were recorded for individuals living in social groups (for example Harvey *et al* 1990, 1991, 1995, 1998, 2001; Clarke *et al* 1993; Harvey and Lindburg 1992, 2001; Lindburg and Harvey 1996). Information on the females' menstrual cycle, signs of menstruation, females' copulatory call and ratings of sexual skin was monitored periodically.

1.6.4. Problems faced in Indian zoos

In Indian zoos, 53 lion-tailed macaques are distributed across 18 zoos, of which several institutions house them singly due to a shortage of captive animals (for example Mallapur & Choudhury 2003; Mallapur in press). Hence, lion-tailed macaques breed only in the Arignar Anna Zoological Park, Chennai in the country while the populations in other zoos are slowly reducing in size due to the mortality of the older individuals. In several cases, these animals are housed in sub-optimal facilities, which have been proved, in the past, to negatively influence the behavioural repertoires of these captive non-human primates (Mallapur & Choudhury 2003; Mallapur in press). Due to poorly maintained animal records in the past and the inability of animal keepers to identify individual animals, certain sub-populations are also inbred. The reproductive physiology and behaviour are yet to be monitored periodically for the entire population making, it difficult to identify proven breeders in order to choose individuals to establish a long-term breeding programme. The immediate need to study the captive lion-tailed macaque population in India in order to identify factors influencing their behaviour and welfare led to the design of this study.

1.7. CONCLUSIONS

Basic and applied research, both in captivity and in the wild, have been conducted by biologists on the behaviour and other biological aspects of species they intend to breed in captivity, with the ultimate aim of reintroducing them into their natural habitats. This has considerably increased the success of the breeding and reintroduction phases of their conservation breeding programmes. The lion-tailed macaque is one such endangered non-human primate, whose successful breeding in zoological parks and breeding centres could lead to self-sustaining captive populations for possible future reintroduction into the wild. Such attempts are extremely important in complementing other *in situ* conservation efforts in saving this species from extinction. Though scientists and zoo-biologists have managed to breed this species in American and European zoos, a well-designed conservation breeding programme is yet to be initiated in India, the very country where the species is endemic. The failure of the Indian captive lion-tailed macaques to breed successfully appears not to be a species-specific problem, but one possibly due to poor husbandry protocols and bad management of the species in captivity. Therefore, there is a need to determine the factors that influence the behaviour, welfare and reproductive success of the Indian captive lion-tailed macaque population in order to establish a successful breeding programme. Hence, monitoring behaviour and welfare would be imperative in establishing a breeding programme for this species and the need to initiate long-term applied behavioural research has been emphasised in this review.

1.8. AIMS OF THIS STUDY

The aims of this study are:

1. To record levels of abnormal behaviour exhibited by captive lion-tailed macaques and to identify the factors that influence their exhibition
2. To devise adequate feeding and structural enrichment techniques for captive lion-tailed macaques in Indian zoos in order to influence them to exhibit a more natural behavioural repertoire
3. To study the difference between breeding and non-breeding groups of captive lion-tailed macaques and to record the factors that influence their reproductive success
4. To study the influence of visitors on the behaviour and welfare of captive lion-tailed macaques and to record visitors' perception of their zoo visit.
5. To identify indicators to assess the welfare of these individuals housed in Indian zoos

CHAPTER II *General Methods*

CONTENTS

2.1. GENERAL METHODS

The behavioural study in Chapter IV was conducted using a total of 51 captive lion-tailed macaques (Table 2.1). The total captive lion-tailed macaque population in India consists of 58 animals, which includes the 51 on which the behavioural study was conducted. The remaining seven individuals include two males that were housed off-exhibit in the Arignar Anna Zoological Park, Chennai and hence were not included in the behavioural study, and five singly-housed individuals housed in five zoos that were only included in the questionnaire study in Chapter III.

All 51 individuals were studied during the preliminary phase of the research (see Chapters IV, VI – Section A – Study 1, VII and VIII). The following chapters (V and VI – Section A – Study 2 and Section B) describe studies carried out on the southern Indian subset of the zoo macaque population which included the animals housed at the Arignar Anna Zoological Park in Chennai, the Shri Chamarajendra Zoological Gardens in Mysore and the Thiruvananthapuram Zoo in Thiruvananthapuram (Table 2.1).

2.1.1. Study sites

This study was conducted on captive groups of lion-tailed macaques housed in 13 zoos in India (Table 2.1; also refer to India map in Plate 2.1). These zoos were classified as Large, Medium and Small zoos according to the Central Zoo Authority classification (see Table 2.2 for classification of zoos, http://cza.nic.in/index1.html, 05/07/04, 1640 h). The zoos were also segregated into those that were situated outside the city and those situated within the city for the purpose of data analyses. Zoos situated within cities have more visitors per day than zoos situated outside the cities because they are accessible. However, city zoos are smaller in size than zoos outside city limits due to the problem of land and space within cities. Due to these marked differences between the two, zoos were segregated in this fashion. Data collection commenced in June 2002 and ended in January 2004. The study period could range from seven to 10 days (for one group) in some places. The time spent at each zoo depended on the number of lion-tailed macaques housed in that zoo. The study was conducted at the following zoos:

1. Arignar Anna Zoological Park (AAZP), Chennai, Tamil Nadu state
2. Guindy Children's Park (GCP), Chennai, Tamil Nadu state
3. Jaipur Zoo (JZ), Jaipur, Rajasthan state
4. Mahendra Chaudhury Zoological Park (MCZP), Chandigarh, Punjab state
5. Maitri Baagh Zoo (MBZ), Bhilai, Chhattisgarh state
6. Mini Zoo (MZK), Kodanad, Kerala state
7. Mini Zoo (MZT), Thattekkad, Kerala state
8. Nandankanan Biological Park (NBP), Bhubaneshwar, Orissa state
9. National Zoological Park (NZP), New Delhi, Delhi state
10. Patna Zoo (PZ), Patna, Bihar state
11. Shri Chamarajendra Zoological Gardens (SCZG), Mysore, Karnataka state
12. State Museum and Zoo (SMZ), Thrissur, Kerala state
13. Thiruvananthapuram Zoo (TZ), Thiruvananthapuram, Kerala state

Table 2.1 Lion-tailed macaques studied in Indian zoos

Zoo[1]	Size	Number of lion-tailed macaques		Enclosure features
	Location[2]	Total group size[3]	Group composition[4]	
AAZP	Large, outside	12 (5:2:5)	1:1:2[5], 1:0:1, 1:0:0, 0:2:0	Cage[5]; wet moat; rest cages
GCP	Small, within	2 (1:1:0)	1:1:0	Cage
JZ	Large, within	3 (1:1:1)	1:1:1	Wet moat
MCZP	Large, outside	2 (2:0:0)	2:0:0	Wet moat
MBZ	Small, within	4 (2:1:1)	1:0:0, 1:0:0, 0:1:1	All cages
MZK	Mini, outside	4 (3:1:0)	1:1:0, 1:0:0, 1:0:0	All cages
MZT	Mini, outside	2 (1:1:0)	1:0:0, 0:1:0	Cage
NBP	Large, outside	2 (1:1:0)	1:1:0	Wet moat
NZP	Large, within	2 (1:1:0)	1:1:0	Cage
PZ	Large, outside	3 (1:2:0)	1:2:0	Wet moat
SCZG	Large, within	5 (2:3:0)	1:3:0, 1:0:0	Dry moat; cage
SMZ	Small, within	3 (3:0:0)	1:0:0, 1:0:0, 1:0:0	All cages
TZ	Large, within	7 (3:4:0)	1:4:0, 1:0:0, 1:0:0	Dry moat; all others cages

[1] The full names of the zoos have been mentioned in the text (see section 2.1.1.).
[2] Refer Table 2.2 for zoo classification; location as within (the town or city) or outside (the town or city).
[3] The composition of groups housed separately at each zoo has been included in brackets.
[4] Refers to the number of sexually mature males: sexually mature females: young (infants and juveniles).
[5] The type of enclosure housing each group in each zoo has been given in the same order. Refer to definitions for enclosure features in the text (see section 2.1.4.).

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Table 2.2 Classification of Indian zoos according to the Recognition of zoos rules (2001)

	Zoo categories			
	Large	Medium	Small	Mini
Number of animal exhibited	> 750	500-750	200-499	< 200
Number of species exhibited	> 75	50-75	20-49	< 20
Number of endangered species exhibited	> 15	10-15	5-9	-
Number of animals of endangered species exhibited	> 150	100-149	50-99	-

2.1.2. Animal husbandry

The feeding time and the time at which the animal keepers cleaned the enclosures varied across zoos (Table 2.3). The diet charts also varied considerably across zoos as well (Table 2.4). In India, most zoos are closed to the public once a week. This system was set up to reduce visitor disturbance and also to give the staff time to carry out certain duties that are not possible when the zoos are open.

Table 2.3 Animal husbandry protocols followed by animal keepers for lion-tailed macaque exhibits in the study zoos

Zoos	Feeding time*	Keeper (cleaning) time	Zoo holiday
AAZP & GCP	12:30 OF	09:00 to 10:00	Tuesday
JZ	09:00 ON, 11:30 ON, 15:00 OF	08:00 to 10:00	Tuesday
MCZP	11:30 OF, 16:00 OF	09:30 to 10:30	Monday
MZK	08:00 ON, 15:30 ON	09:00 to 11:00	No holiday
MZT	09:00 ON, 14:00 ON	09:00 to 11:00	No holiday
NBP	11:30 OF	07:30 to 08:30	Monday
NBZ	11:30 ON	08:00 to 10:00	Monday
NZP	11:30 ON	10:00 to 11:00	Friday
PZ	15:00 OF	08:30 to 09:30	Monday
CZG	11:30 OF, 13:30 ON, 17:00 OF	09:00 to 11:00	Tuesday
SMZ	11:30 ON, 15:30 ON	09:00 to 11:00	Monday
TZ	12:30 OF, 16:00 OF	09:00 to 10:00	Monday

* Animals were fed either on-exhibit (ON) or off-exhibit (OF)

Table 2.4 Diet charts followed in the study zoos for lion-tailed macaques fed per individual per day

Per animal	Fruits*	Vegetables*	Cereals*	Nuts*	Bread*	Boiled egg*	Milk**
AAZP & GCP	300	125	60	25	150	25	0
JZ	300	475	100	100	100	50	0
MCZP	215	610	25	25	0	0	0
MZK	375	100	50	125	0	25	0
MZT	300	25	150	125	0	0	0
NBP	250	350	100	50	30	0	10
NBZ	250	150	150	50	0	50	0
NZP	300	450	150	50	100	50	100
PZ	350	250	600	500	100	0	0
SCZG	350	200	50	125	150	25	100
SMZ	375	100	25	125	0	25	0
TZ	305	220	80	35	235	25	0

* Expressed as grams; ** Expressed in millilitres

2.1.3. Study individuals

Data collected on the behavioural profiles of the study animals were compared across different categories classified according to their individual characteristics, enclosure and management details. Individual information on the age, identity, sex and rearing history of all the lion-tailed macaques housed at each zoo were collected from the zoo records. The parameters considered include:

A. Age: Five age categories (Table 2.5):

i. Infant (up to 1 year)
ii. Juvenile (1 year to 3 years)
iii. Sub-adult (3 to 5 years in females; 3 to 8 years in males)
iv. Adult (5 to 15 years in females; 8 to 18 years in males)
v. Old (beyond 15 years in females; beyond 18 years in males)

B. Sex: Two categories:

i. Male
ii. Female

C. Rearing History: Four classes (Table 2.5):

i. Wild-caught (individuals acquired from the wild in the last 5 years)

ii. Captive-reared (individuals acquired from the wild but in zoos for > 5 years)

iii. Zoo-born (individuals born in zoos; according to zoo records, all individuals were housed with conspecifics during the first few years of life)

iv. Confiscated (individuals confiscated from private owners, unrecognised zoos and from circuses/peddlers; according to zoo records, most animals were confiscated while juveniles or sub-adults before which the animals were housed in isolation. Hence, these individuals have been referred to as isolate-reared)

Table 2.5 Age and rearing history details of lion-tailed macaques studied in Indian zoos

Zoos[1]	Group composition[2]	Age[3]	Rearing history[4]
AAZP	1:1:2[5], 1:0:1, 1:0:0, 0:2:0	9:7:3,1[5], 18:0:2, 7:0:0, 0:5,4:0,	Z:Z:Z,Z[5], W:0:Z, Z:0:0, 0:Z,C:0
GCP	1:1:0	9:6:0	Z:Z:0
JZ	1:1:1	7:9:3	Z:Z:Z
MCZP	2:0:0	16,25:0:0	Z,Z:0:0
MBZ	1:0:0, 1:0:0, 0:1:1	16:0:0, 18:0:0, 0:12:1	Z:0:0, Z:0:0, 0:Z:Z
MZK	1:1:0, 1:0:0, 1:0:0	14:20:0, 20:0:0, 14:0:0	C:C:0, C:0:0, C:0:0
MZT	1:0:0, 0:1:0	11:0:0, 0:10:0	C:0:0, 0:C:0
NBP	1:1:0	16:26:0	Z:Z:0
NZP	1:1:0	15:21:0	Z:Z:0
PZ	1:2:0	11:7,10:0	C:Z,C:0
SCZG	1:3:0, 1:0:0	20:19,17,9:0, 19:0:0	C:Z,C,C:0, C:0:0
SMZ	1:0:0, 1:0:0, 1:0:0	12:0:0, 14:0:0, 18:0:0	C:0:0, C:0:0, C:0:0
TZ	1:4:0, 1:0:0, 1:0:0	16:16,14,5,5:0, 8:0:0, 21:0:0	C:Z,C,C,C:0, C:0:0, CB:0:0

[1] The full names of the zoos have been mentioned in the text (see section 2.1.1.).

[2] Refers to the number of sexually mature males: sexually mature females: young (infants and juveniles) and sub adults. The composition of each group has been given separately for each zoo.

[3] Ages of each individual is given group-wise approximated to the nearest year. Actual ages have been tabulated in this column

[4] Rearing history of each individual is given group-wise. Rearing history categories given are C = confiscated, CB = captive-born, Z = zoo-born and W = wild-caught.

[5] Ages and rearing histories for each group in each zoo has been given in the same order as group compositions are given in Table 2.1.

2.1.4. Enclosure details

Five factors relating to enclosure design – enclosure size, type, complexity, substrate type and access to the vertical dimension – were recorded to assess their influence on behaviour.

<u>A. Enclosure size (per group)</u>

i. < 30 m^2
ii. 30-60 m^2
iii. 60-90 m^2
iv. > 90 m^2

<u>B. Enclosure type</u>

i. Cage: area enclosed by wrought-iron bars (see Plates 2.2 & 2.3)
ii. Wet-moated enclosures: surrounded by a moat containing water (see Plate 2.4)
iii. Dry-moated enclosure: surrounded by a steep-walled moat maintained dry

Plate 2.2 Barren cage exhibit for lion-tailed macaques at Mini Zoo, Kodanad

Plate 2.3 Barren but enriched cage exhibit for lion-tailed macaques at Mini Zoo, Thattekad

Plate 2.4 Complex open-moated exhibit for lion-tailed macaques at Arignar Anna Zoological Park, Chennai

C. Enclosure complexity

i. Barren enclosures: enclosures devoid of any structural features other than the four walls, floor and roof (see Plate 2.2)

ii. Barren but enriched enclosures: barren enclosures but structurally enriched with logs or sleeping platforms (see Plate 2.3)

iii. Complex enclosure: enclosures with several natural features including trees, bushes or water bodies that resemble the animals' natural habitat (see Plate 2.4)

D. Substrate type

i. Enclosures with a hard substrate such as cement or concrete (see Plates 2.2 & 2.3)

ii. Enclosures with a soft substrate such as grass and soil (see Plate 2.4)

E. Accessibility to the vertical dimension

i. Enclosures without access to the vertical dimension where the individual has no opportunity to climb within the exhibit (see Plate 2.2)

ii. Enclosures with access to the vertical dimension which gives the individual an opportunity to climb within the exhibit (see Plates 2.3 & 2.4)

The effect of group size and feeding regime on behaviour were also assessed.

A. Group size: the group composition of lion-tailed macaques across Indian zoos depended upon the number of individuals the zoo had in captivity. It was noted that zoos with more than six individuals housed them in groups of one male, one or more females, and young (juveniles and infants). Surplus males were singly-housed. Individual females without young, however, were housed with other females (without young) and with males, either in groups or in pairs. The following categories were used to assess the influence of group composition on behaviour:

i. Singly-housed

ii. Single sex groups (no young)

iii. One male, one female (no young)

iv. One male, two or more females (no young)
v. Single adult (either male or female) with young
vi. One male, female/s (male and female/s) and young

B. Feeding regime: different feeding times were used across the study zoos to feed lion-tailed macaques. The following categories were used to classify feeding routines across zoos so as to determine their influence on behaviour:

i. Only morning feeds (at 0930 h)
ii. Only afternoon feeds (at 1230 h)
iii. Only evening feeds (at 1630 h)
iv. Only morning (at 0930 h) and evening feeds (at 1630 h)
v. Morning (at 0930 h), afternoon (at 1230 h) and evening feeds (at 1630 h)

2.2. BEHAVIOURAL METHODOLOGY

This section describes in detail the behavioural methodology followed in the studies of chapters IV, V, VI (Studies 1A and 1B) and VII. For this study, behaviour was categorised into behavioural events and states. Events were further segregated into individual and social events.

2.2.1. Behavioural events

Behavioural events are discrete, of relatively short duration of one to 10 seconds, and hence, measurable in terms of the frequency of their performance per unit time. Behavioural events were recorded using continuous focal animal sampling (Martin & Bateson 1994) and their frequency calculated as number of events performed per hour. In this study, behavioural events were represented as frequencies per hour (event/h).

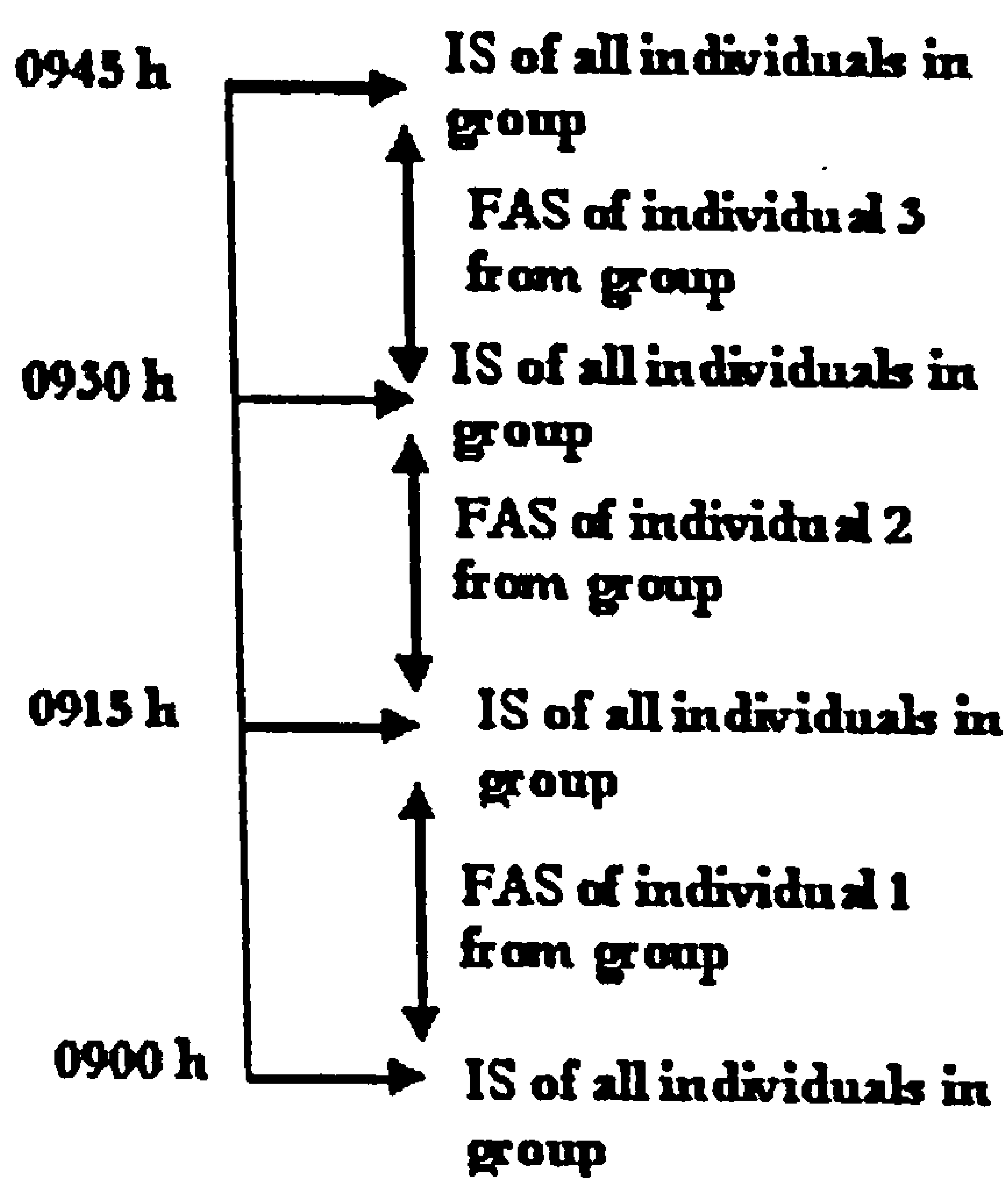
2.2.2. Behavioural states

Behavioural states are of relatively longer duration than behavioural events (30 seconds to several hours), and are usually measured in terms of their total durations as a proportion of the total observed time (Martin & Bateson 1994). In this study, behavioural states were sampled by instantaneous sampling and were expressed as a percentage of the total number of scans (%).

2.2.3. Behavioural sampling

At each zoo, all individuals that were exhibited to the public were studied. To standardise the recording of behaviours exhibited by the study individuals and to develop an ethogram (refer to Chapter IV, Table 4.1; for definitions refer to Appendix 4.1), sampling *ad libitum* was conducted initially per individual for a period of 15 hours over six days. The first two days, behaviour was sampled *ad libitum* from 0830 to 1130 h, on the third and fourth days from 1130 h to 1430 h and on the fifth and sixth day from 1230 to 1730 h. during these sampling sessions, time spent with each group helped in differentiating between animals. Certain rare behaviours that were only seen during subsequent quantitative observations were later described and added to the ethogram (refer to Chapter III, Table 4.1; for definitions refer to Appendix 4.1). Individuals were observed on all days of the week including zoo holidays, which differed across the study zoos.

Plate 2.5 Behavioural sampling methods followed while observing lion-tailed macaques (IS = Instantaneous scans, FAS = Focal animal scans)



At each study zoo for studies conducted in chapters IV, V, VI (Studies 1A and 1B) and VII, all individuals that were exhibited to the public were studied for a period of nine hours during the day between 0830 h, when the zoo opened in the morning and 1730 h, when it closed for the day. Each behavioural sampling session was initiated with an instantaneous scan, and was followed by a focal animal sample of one of the individuals in the group for a duration of 15 min (Plate 2.5). The next scan was conducted after the completion of this focal animal sample. Individuals were sampled in an order, which was decided by the observer on a daily basis before behavioural sampling sessions were initiated. Numbers were allotted to every member of the group. These individual numbers were written on pieces of paper, which were put into a cardboard box and shuffled. Numbers were randomly picked out from the box. Once the order of observing the individuals from a group was obtained, the same order was maintained for all observations made for the group during the day. A new order was obtained in the same fashion the next day. The order of observing the individuals was used only for focal animal scans. During instantaneous scans, individuals were sampled by recording the behaviour of the animals that occurred in the following order: left extreme, then left, middle, right and then right extreme of the enclosure. Each sampling period lasted for one three hours and consisted of 13 instantaneous scans (five instantaneous scan for the first hour as the sampling period was commenced with a scan & four scans for every additional hour) and 12 focal animal samples.

2.3. SPACE USE

Details of the enclosure occupied by the study animals were gathered from zoo records, measurements and from observations made at each zoo (Mallapur *et al* 2002). Details of the enclosures were plotted on a representative map of the enclosure, including trees, shrubs, shelters and other structural features found within the enclosures (Plate 2.6).

To study the space utilisation of the enclosure by an animal, the enclosure was partitioned on paper into four zones –

i. The *edge* zone – the part of the enclosure closest to the visitor area (no enrichment present)

ii. The *back* zone – the part of the enclosure furthest from the visitor area (no enrichment present)

iii. The *enrich* zone – every part of the enclosure containing any structures such as trees, sleeping platforms, sheds, logs, elevated bars, any forms of enrichment and/or water bodies.

iv. The *other* zone – the parts of the enclosure that does not fall into any of the above categories (no enrichment present)

These zones were mutually exclusive and were marked on the base map for all enclosures in which the lion-tailed macaques were observed during the study (Plate 2.6). The sizes of these zones were in proportion to the enclosure size and varied in size across enclosures. The zone occupied by the study animal at a given time was recorded along with behaviour as instantaneous scans. This procedure was followed for all individuals at all the 13 zoos.

Plate 2.6 Enclosure zones marked on a base map for the outdoor lion-tailed macaque exhibit at Thiruvananthapuram Zoo

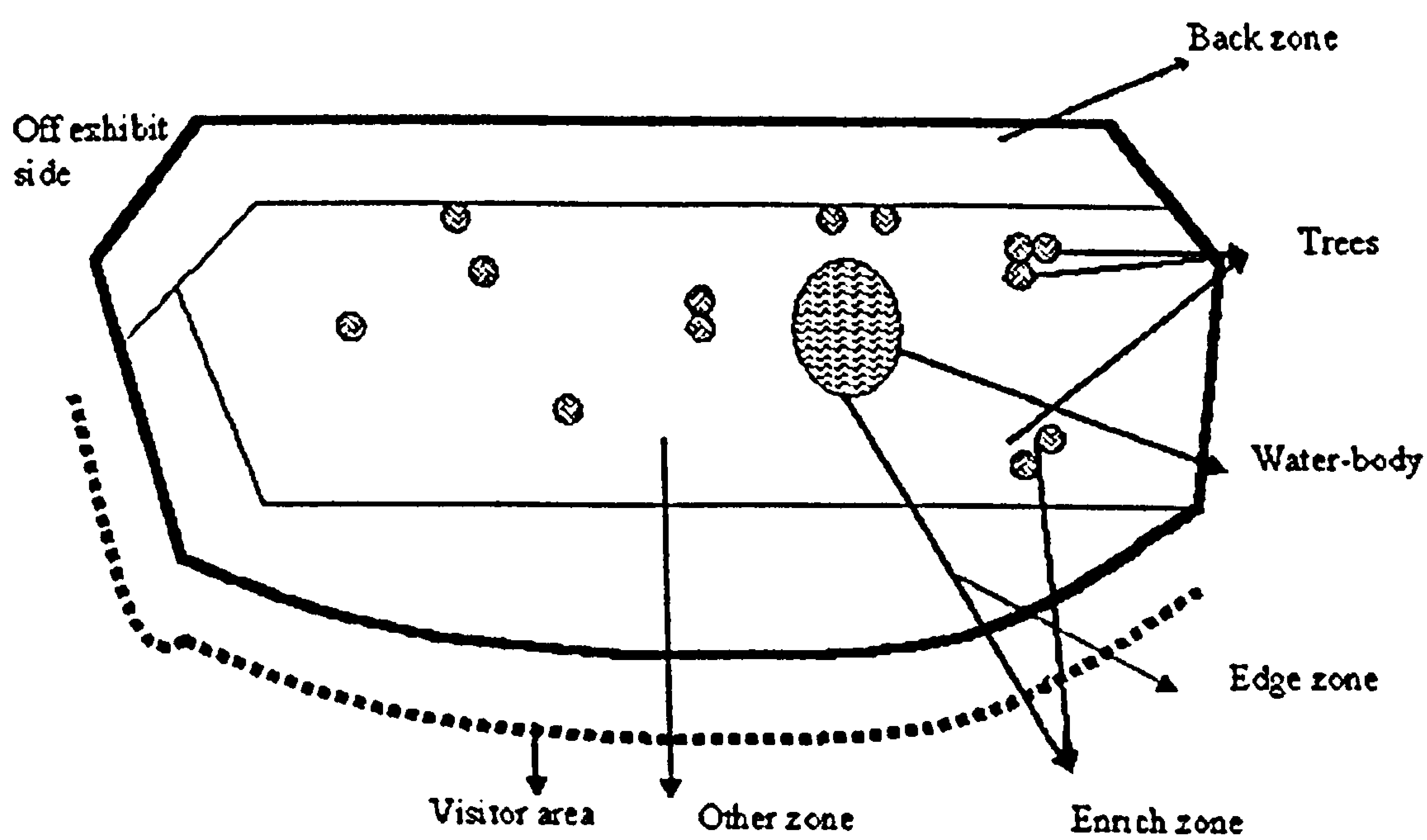
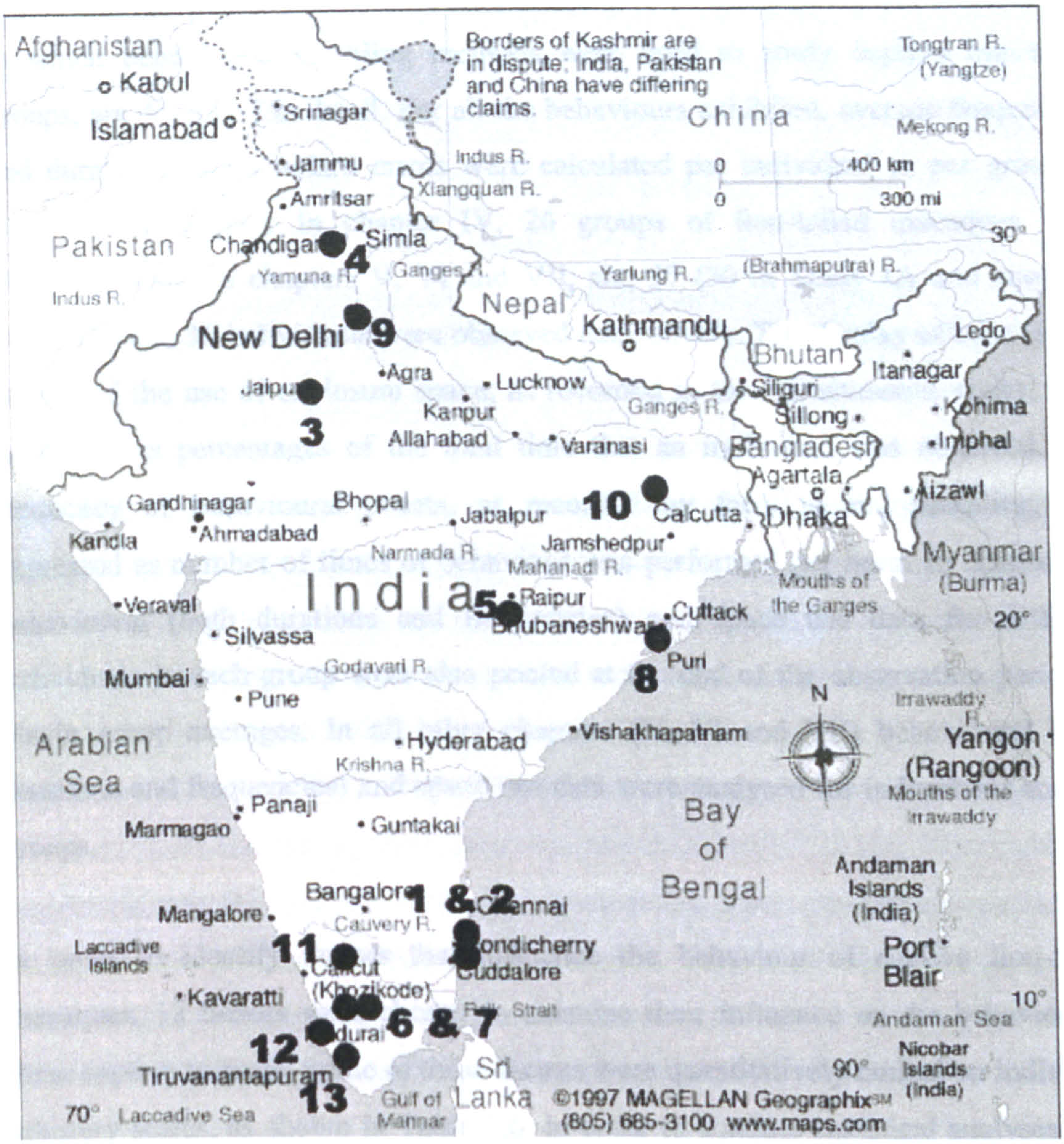


Table 2.6 Ranks for factor categories used to compare behavioural data across captive lion-tailed macaques housed in 13 Indian zoos

Factor	Categories	Ranks*
Zoo category	Small	0
	Medium	1
	Large	2
Zoo type	Within the city	0
	Outside the city	1
Age category	Infant (up to 1 year)	0
	Juvenile (1 year to 3 years)	1
	Sub-adult (3 to 5 in females; 3 to 8 in males)	2
	Adult (5 to 15 for females; 8 to 18 males)	3
	Old (beyond 15 in females; beyond 18 in males)	4
Sex	Male	0
	Female	1
Rearing history	Wild-caught (acquired from the wild in the last 5 yr)	0
	Captive-reared (acquired from wild but in captivity for > 5 yr)	1
	Zoo-born (born in zoos)	2
	Confiscated (confiscated from unrecognised zoos, or circuses)	3
Feeding time	Morning	0
	Afternoon	1
	Evening	2
	Morning and evening	3
	All three times	4
Group Composition	1 male: 2 or more females	0
	1 male: 1 female	1
	Single adult with young	2
	Males, females and young	3
	>1 male: >1 female (no young)	4
	Single sex groups	5
	Singly-housed	6
Enclosure size	< 30 m^2	0
	30-60 m^2	1
	60-90 m^2	2
	> 90 m^2	3
Enclosure type	Cage	0
	Wet-moat	1
	Dry-moat	2
Enclosure complexity	Barren	0
	Barren but enriched	1
	Complex	2
Substrate	Hard	0
	Soft	1
Vertical dimension	No access	0
	With access	1

*These ranks were only used for statistical analyses to study the influence of the factors listed above on behaviour

Plate 2.1 Map of India with the 13 study zoos numbered as given in Section 2.1.1 Study sites



1. Arignar Anna Zoological Park (AAZP), Chennai, Tamil Nadu state
2. Guindy Children's Park (GCP), Chennai, Tamil Nadu state
3. Jaipur Zoo (JZ), Jaipur, Rajasthan state
4. Mahendra Chaudhury Zoological Park (MCZP), Chandigarh, Punjab state
5. Maitri Baagh Zoo (MBZ), Bhilai, Chhattisgarh state
6. Mini Zoo (MZK), Kodanad, Kerala state
7. Mini Zoo (MZT), Thattekkad, Kerala state
8. Nandankanan Biological Park (NBP), Bhubaneshwar, Orissa state
9. National Zoological Park (NZP), New Delhi, Delhi state
10. Patna Zoo (PZ), Patna, Bihar state
11. Shri Chamarajendra Zoological Gardens (SCZG), Mysore, Karnataka state
12. State Museum and Zoo (SMZ), Thrissur, Kerala state
13. Thiruvananthapuram Zoo (TZ), Thiruvananthapuram, Kerala state

2.4. DATA ANALYSES

In this section, the analyses used in chapters (IV, V, VI (Studies 1A and 1B) and VII) in which behavioural sampling methods were used to study captive lion-tailed groups, are described in detail. For all the behaviours exhibited, average frequencies and durations, and standard errors were calculated per individual or per group of lion-tailed macaques. In chapter IV, 26 groups of lion-tailed macaques were observed, while in chapters V, VI and VII, six, 37 (30 in Study 1A and seven in Study 1B) and 36 individuals were observed respectively. The display of behavioural states and the use of enclosure space, as recorded in the instantaneous scans, were expressed as percentages of the total time that an individual was observed. The frequency of behavioural events, as recorded by focal animal sampling, was expressed as number of times of behaviour was performed per hour. In chapter IV, behavioural (both durations and frequencies) and space use data for different individuals in each group were also pooled at the end of the observation period to obtain group averages. In all other chapters (V, VI and VII) behavioural (both durations and frequencies) and space use data were analysed for individuals and not groups.

In order to identify factors that influence the behaviour of captive lion-tailed macaques, 12 factors were chosen to examine their influence on the behaviour of these captive animals. Some of these factors were quantitatively ranked on individual arbitrary scales, as shown in Table 2.6, in order to conduct statistical analyses. The same ranking system was used in all chapters that included behavioural studies (IV, V, VI (Studies 1A and 1B) and VII). For studies (Chapters IV & VII) in which behavioural data were pooled group-wise to maintain social independence of data points, factors such as rearing history and age were pooled group-wise too to conduct the analyses. Of the study individuals, only one was captive-reared and one other was wild-caught. Hence, groups invariably consisted of individuals that were either confiscated (rank category 3, refer Table 2.6) or zoo-born (rank category 2, refer Table 2.6) which resulted in the pooled rank remaining between 2 and 3.

Since the behavioural and space use data recorded were not normally distributed and since the degree of variance was high, non-parametric statistics were used for data analyses. Normality of the behavioural data was tested using the Kolmogorov-Smirnov test (Siegel & Castellan 1988). The non-parametric tests used to analyse behavioural and space use data for all chapters that included behavioural studies (IV, V, VI (Studies 1A and 1B) and VII) has been given in detail below. However, although medians and inter-quartile ranges are more appropriate to depict non-normal data, means were used in all behavioural studies in this thesis.

2.4.1. The Friedman two-way analysis for variance by ranks test

The Friedman's two-way analysis of variance test (FV) was used to analyse differences across the different behavioural categories and enclosure zones for chapters IV, V and VI (Studies 1A and 1B). In chapter V, the FV test was also used to investigate the differences in percentage behaviour exhibited and space used between the five phases of the structural enrichment study (Study A). The Friedman's two-way analysis of variance is a non-parametric test used to determine if three or more samples on the same individuals (Chapters V and VI) or groups (Chapter IV) are significantly different (Lehner 1996). Since the number of samples is matched, the number of cases is the same in each of the samples (Siegel & Castellan 1988). In this study, this matching was achieved by studying the same individuals or groups under a number of conditions.

If the difference between the samples was significant, post-hoc analysis was conducted to identify the pairs of samples, which were significantly different (Siegel & Castellan 1988).

2.4.2. The Kruskal-Wallis one-way analysis of variance by ranks test

The Kruskal-Wallis one-way analysis of variance by ranks (KW) is a test used for determining whether three or more independent samples are significantly different (Lehner 1996). In Chapter IV, the KW test was used to examine the differences in behaviour and space use between the various rank categories for the variables having three or more independent samples listed in Table 2.6. Partial-correlations were conducted on the samples that showed a significant difference using the KW test. This test was used to validate the KW test and to correct for factors that were simultaneously acting on the behaviour and space use. If the partial correlations conducted also presented significant results, and then post-hoc analysis was done to identify the individual pairs, which had a significant difference.

The KW test was also used in Chapter VII to determine the differences in behaviour and space use between breeding, non-breeding and singly-housed lion-tailed macaque individuals. In order to identify the individual pairs in which the difference is significant, post-hoc analysis was conducted.

2.4.3. The Wilcoxon-Mann-Whitney test

The Wilcoxon-Mann-Whitney test (U) is the nonparametric equivalent of the independent samples t-test (Dytham 1999). This test is one of the most powerful nonparametric tests (Siegel & Castellan 1988). The test is used to determine whether two independent samples have been drawn from the same population. In Chapter IV, the U test was used to examine the differences in behaviour between the various rank categories for the variables having two independent samples listed in Table 2.6. Partial-correlations were conducted on the samples that showed a significant difference using the U test. This test was used to validate the U test and to correct for factors that were simultaneously acting on the behaviour. The U test was also used in Chapter VII to determine the differences between breeding and non-breeding individuals.

2.4.4. The Wilcoxon signed ranks test

The Wilcoxon Signed Ranks Test (WRT) is the equivalent of the paired t-test (Dytham 1999). This test is used in the case of two related samples in order to determine if there is a significant difference between them (Siegel & Castellan 1988). The WRT test was used in Study B in Chapter V to determine the difference between the behaviour and space used by individuals when they were singly-housed

housed and group housed. The test was also used in Study 1A and 1B in Chapter VI to determine the differences in individual behaviour and space use on visitor presence days and visitor absence days. The data were pooled and then ranked for this test (Siegel & Castellan 1988).

2.4.5. The Spearmans rank order correlation coefficient

The Spearmans Rank Order Correlation Coefficient (SPT) is a measure of the association between two variables, which requires that both variables be measured in ordinal scale. The SPT test is used as the nonparametric equivalent of the Pearson's product-moment correlation test (Dytham 1999). The SPT correlation coefficient is denoted as r_s and ranges from -1 through 0 to 1 indicating 'prefect negative correlation', 'no correlation' and 'perfect positive correlation' respectively. This test was used in Chapter IV to correlate behaviours exhibited to the enclosure space used. These behaviour-space use correlations were conducted to check with certain behaviours were predominantly exhibited in certain enclosure zones.

2.4.6. Part Correlation test (PC)

The partial correlation coefficient (PC) is the measure of the relationship between two variables when one or more other variables have been held constant. In Chapter IV, partial correlations were conducted to measure the influence of one of the factors listed in Table 2.6 on behaviour when one or more other factors were held constant. First, the KW test was conducted for factors having three or more independent samples and U test for factors having two independent samples was conducted to identify the factors influencing a particular behaviour (for behaviour list, refer to Table 4.1 in Chapter IV). If more than one factor significantly influenced a particular behaviour, then partial correlations were conducted to test if the factors influence on the behaviour persisted even after holding the other factor having a significant influence on the same behaviour constant. A factor was said to significantly influence a particular behaviour only if the p value was significant after conducting partial correlations while holding all the other factors that significantly influenced the same behaviour constant. The significant results were interpreted by consulting the initial analysis (for example U test for comparisons between two independent samples and post-hoc analysis for the KW test conducted for comparisons between three or more independent samples).

CHAPTER III *Questionnaire Survey*

CONTENTS

A World Survey of Husbandry Practices Experienced by Captive Lion-tailed Macaques (*Macaca silenus*)

3.1. ABSTRACT

A questionnaire survey was conducted to compare husbandry and management protocols for lion-tailed macaques in 42 zoos in various parts of the world: including 18 Indian zoos and 24 zoos elsewhere in Africa, Asia, Australasia, Europe and North America. The results showed that, in general, Indian zoos have relatively few animals and most of these are housed in isolation without enrichment. In contrast, zoos outside India maintained their animals in social groups in more naturalistic enclosures and provided them with enrichment. A relatively higher number of the zoos outside India compared to Indian zoos reported foraging behaviour in their individuals, while abnormal behaviour was rare. The reproductive success of the macaques in these zoos was also significantly higher than that in Indian zoos. The results of this chapter suggest that group composition, enclosure design, dietary preparation and nutrition, as well as visitor-animal interaction could influence the welfare and breeding success of lion-tailed macaques in Indian zoos.

Key words: India, questionnaire, animal welfare, abnormal behaviour, reproductive success

3.2. INTRODUCTION

The critical role of the 'modern zoo' in care, maintenance and welfare of captive animals has helped realise the four basic directives of conservation, education, research and recreation. It is strongly believed by the zoo community worldwide that zoos should improve and increase their research output in order to advance their *ex situ* conservation objectives (Maple *et al* 1995). Wiese and Hutchins (1997) suggest that obtaining information on the biology and behaviour of a species is vital if breeding efforts are to be successful in maintaining a long-term captive population. For example, in the 1980's intensified effort and advanced management techniques carried out at a small number of American zoos caused the captive lion-tailed macaque population in North America to double in size (Lindburg *et al* 1997). Individuals were carefully chosen to meet both genetic and social objectives in order to create breeding groups that would be able to maintain a stable core population in captivity. Enclosures were specifically designed to provide a favourable environment for animals' to exhibit a variety of natural behaviours. These behavioural and social requirements of the animals were met by administering enrichment and by maintaining them in species-appropriate groupings. A breeding programme was also set up involving several institutions. Similar captive breeding programmes for endangered non-human primates were set up worldwide and several species bred successfully during these programmes (Cox 1997; Stoinski *et al* 1997).

In India, there are currently no breeding programmes for any non-human primate species. Such programmes, however, need to be initiated, particularly for endangered species such as the lion-tailed macaque, a primate endemic to peninsular India. Moreover, several institutions in India house lion-tailed macaques singly due to a shortage of captive animals. Hence, the captive lion-tailed macaque population in India is slowly reducing in size due to the mortality of the older individuals and low breeding success (Mallapur & Choudhury 2003; Mallapur in press). These animals are often housed in sub-optimal facilities, which have been found to adversely influence the behavioural repertoire of captive non-human primates (for example Rendall & Taylor 1991; Buchanan-Smith 1996, 1997; Mallapur & Choudhury 2003;

Mallapur in press). Presently, lion-tailed macaques are breeding in only one of the 18 Indian zoos that maintain them (Mallapur in press). In stark contrast, zoos in the developed countries have bred lion-tailed macaques so successfully that these programmes have had to be subsequently controlled, owing to a serious shortage of space to house the burgeoning population of macaques (Lindburg *et al* 1997).

3.3 AIM

The aim of this chapter is to identify factors that could influence the welfare and reproductive success of the Indian captive population of the lion-tailed macaque. This is achieved by using a questionnaire survey to collect information on zoo management practices and lion-tailed macaque husbandry in zoos across the world and in India.

3.4. METHODOLOGY

3.4.1. Study sites

Sixty zoos outside India house lion-tailed macaques (Table 3.1). This information was obtained from the International Species Information System (http://www.isis.org /abstracts/abs.asp, 15/01/02) and from regional studbook keepers. The questionnaire was sent to all zoos abroad, which were housing lion-tailed macaques in March 2002. All 18 Indian zoos housing lion-tailed macaques were also sampled.

3.4.2. Questionnaire design

To compare the lion-tailed macaque management and husbandry protocols followed in zoos outside India with those in Indian zoos, a questionnaire survey was conducted (refer to Appendix 3.1 for questionnaire). The questionnaire consisted of a

Table 3.1 Information from zoos housing lion-tailed macaques worldwide

A. Information from zoos outside India		
Country	Number of zoos*	Total number of animals**
Australia	1/1	2:2:0
Canada	2/3	6:8:1
China	0/1	-
Czech Republic	3/4	7:13:5
France	2/4	4:3:3
Germany	1/9	3:3:2
Hungary	0/2	-
Ireland	0/1	-
Israel	0/2	-
Japan	0/1	-
Malaysia	0/1	-
Netherlands	1/1	2:1:1
Poland	1/1	3:2:0
Portugal	1/2	2:0:0
Russia	0/1	-
Singapore	1/1	6:5:0
South Africa	1/1	2:2:0
Spain	1/1	2:0:0
UK	3/4	6:8:6
USA	6/19	9:13:0
Total	24/60	54:60:18

B. Information from Indian zoos	
Study zoos	Number of animals
Bhilai, Chhattisgarh state	2:1:1
Chennai, Tamil Nadu state	5:4:3
Chhattbir, Punjab state	2:0:0
Guindy, Tamil Nadu state	1:1:0
Guwahati, Assam state	0:1:0
Hyderabad, Andhra Pradesh state	1:0:0
Jaipur, Rajasthan state	2:1:0
Kanpur, Uttar Pradesh state	0:1:0
Kodanad, Kerala state	3:1:0
Kolkata, West Bengal state	0:1:0
Mysore, Karnataka state	2:3:0
Nandankanan, Orissa state	1:1:0
New Delhi, Delhi state	1:1:0
Patna, Bihar state	1:2:0
Pune, Maharashtra state	1:0:0
Thattekkad, Kerala state	1:1:0
Thiruvananthapuram, Kerala state	5:4:0
Thrissur, Kerala state	3:0:0
Total	31:23:4

* Represented as a ratio of the number of zoos that responded to the questionnaire to the total number of zoos that the questionnaires were sent to

** Number of total sexually mature males: sexually mature females: young (infants and juveniles) combination of 15 closed and two open-ended questions, and some of the closed questions were ranked on a scale so as to be able to rate the report from one zoo in comparison to reports from other zoos (http://www.statpac.com/surveys/, 23/07/02).

In zoos outside India, the animal keeper staff responsible for the primate section or the registrar filled in the questionnaire. However, in India the researcher filled in these questionnaires. This method was followed in Indian zoos because these zoos did not have a registrar and the keepers could not fill in the forms. However, it must be noted that the use of different techniques to fill in the questionnaires in zoos outside India and Indian zoos could have led to a sampling bias, which could have influenced the results of the study.

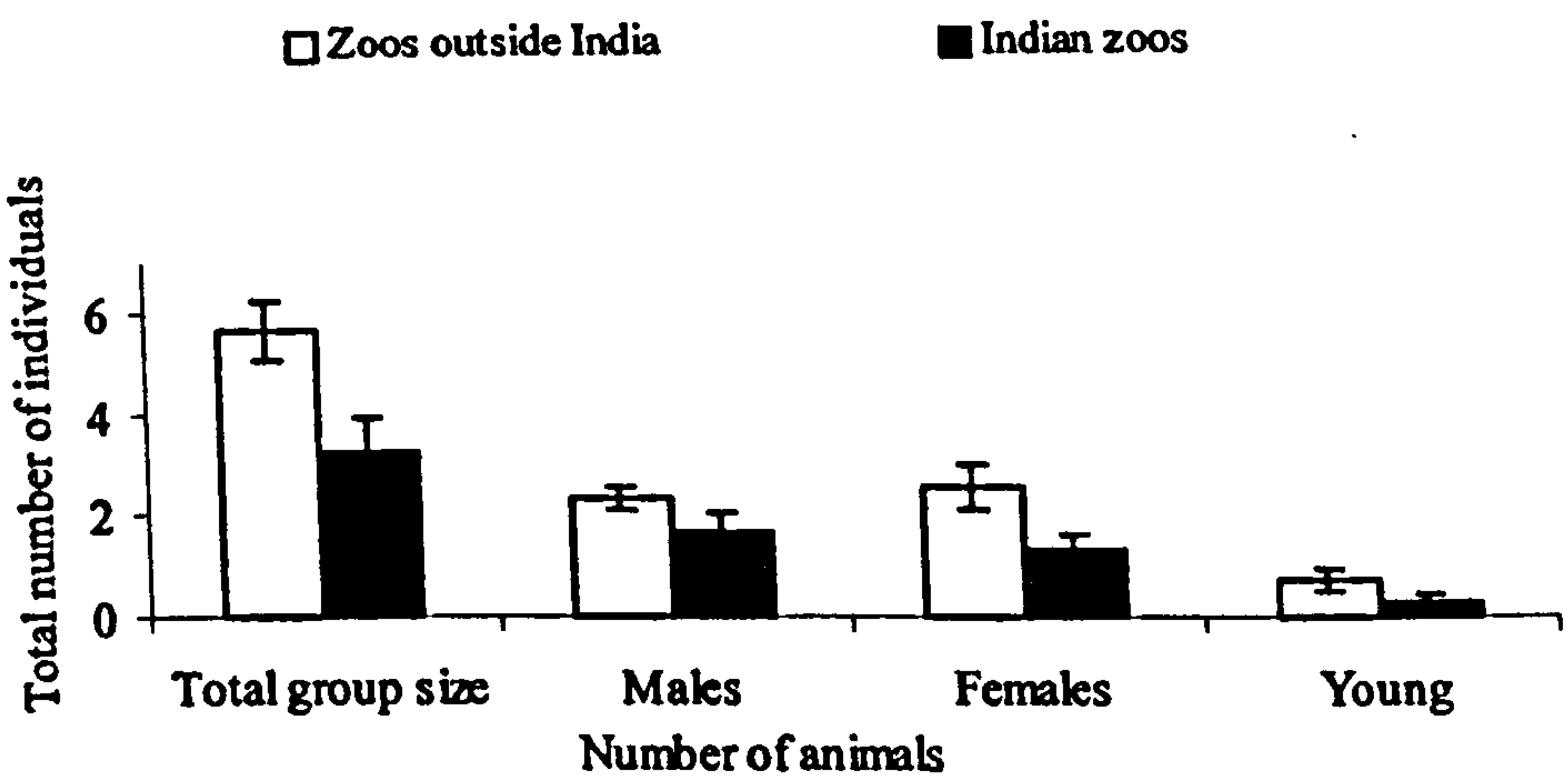
3.4.3. Data analyses

Since the sample size for this study was small, consisting of a total of 78 zoos housing lion-tailed macaques worldwide, the census method of enumeration was used in this study (http://www.statpac.com /surveys/sampling.htm, 27/03/03). The census method is used in studies concerning small sample sizes and involves sampling every member of the population; hence questionnaires were posted to all zoos outside of India and filled in for all zoos within India. The Mann-Whitney U-test (Siegel & Castellan 1988) was used to test for differences between captive populations outside India and within India. Since the data obtained through the questionnaire survey was nominal, frequencies, ratios and percentages have primarily been used to represent the results of these analyses. Most of the comparisons made using Mann-Whitney U-test used sample sizes of 24 questionnaires from zoos outside India in comparison to the 18 questionnaires from Indian zoos, a total of 42 zoos worldwide. Of these 42 zoos, only 17 zoos outside India and 12 Indian zoos housed the lion-tailed macaques in groups. Hence only reports from these 17 zoos outside India were compared to the 12 Indian zoos for analyses concerning breeding and reproductive success of the lion-tailed macaques. All P values that have been reported are two-tailed. SPSS (Version 7.5) was used to perform the statistical tests.

3.5. RESULTS

Of the 60 zoos outside India that were contacted, 24 zoos responded to the postal questionnaire survey, which is a reply rate of 40%. From seven of these countries, none of the zoos replied; 71.4 % of these were Asian countries. Most of the zoos that did reply were from Australia, North America or Europe (84.6%).

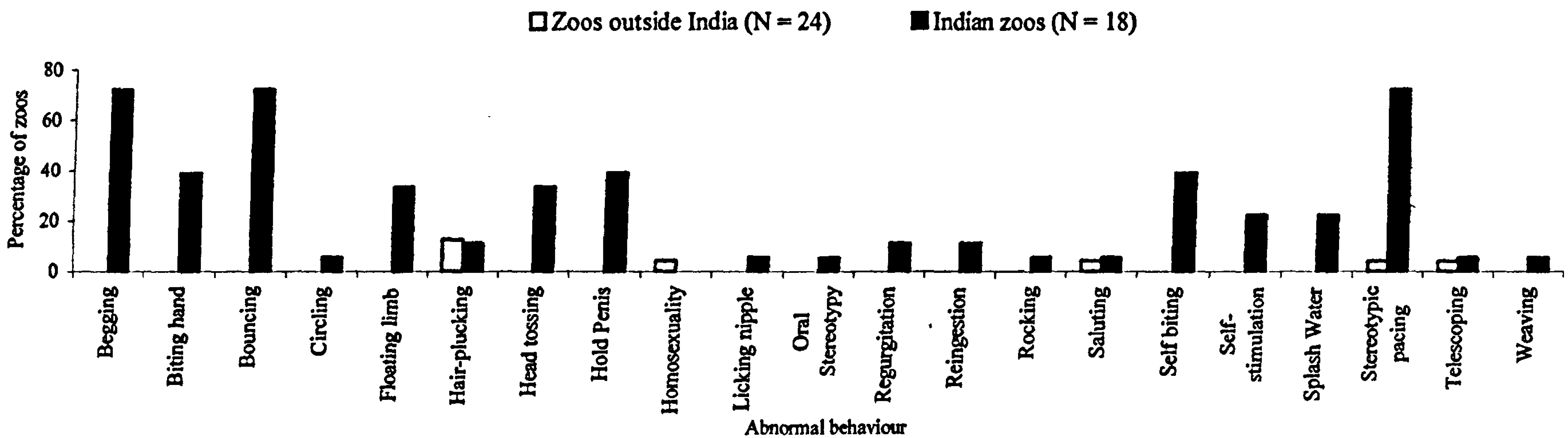
Figure 3.1 Average number of lion-tailed macaques housed in zoos worldwide



3.5.1. Demography of captive lion-tailed macaque groups

The average number of captive lion-tailed macaques in zoos outside India was significantly higher than in the Indian zoos (Figure 3.1, total number of individuals per zoo: Mann- Whitney $U = 92.5$, $N = 24$ (zoos outside India) and 18, (Indian zoos), $P < 0.005$; percentage of males: $U = 130.0$, $P < 0.05$; percentage of females: $U = 132.5$, $P < 0.05$). The male: female sex ratio was 1: 1.11 in the international captive stock of lion-tailed macaques but only 1: 0.72 in the Indian stock. There was a significant difference in the number of individuals and composition in which the macaques were housed in Indian zoos and outside India ($U = 120.0$, $N = 24$ and 18, $P < 0.0005$). Macaques were invariably housed in pairs or groups in all the zoos outside India while in India, only 55.6% of the zoos housed their captive animals in pairs or groups, the rest being housed in isolation.

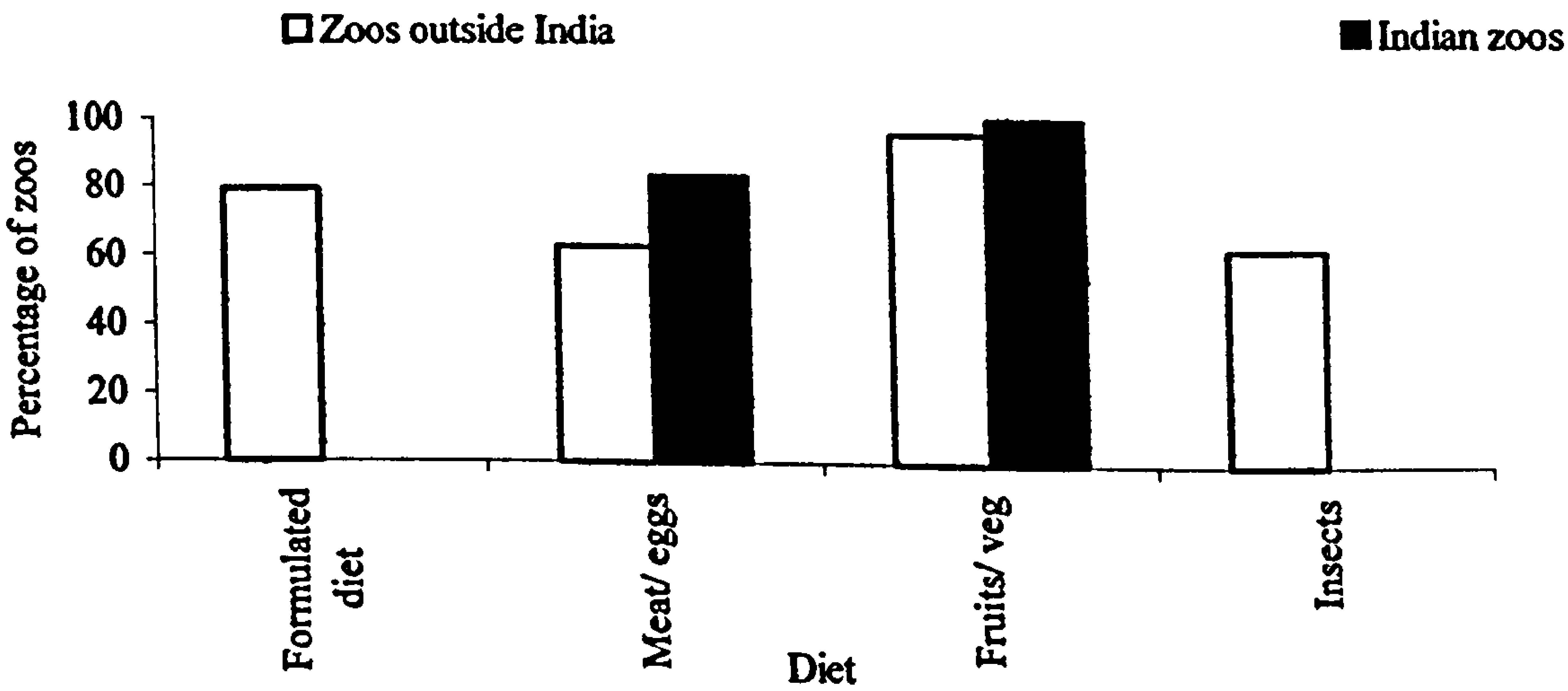
Figure 3.2 Abnormal behaviours exhibited by lion-tailed macaques in zoos worldwide



3.5.2. Behavioural differences between captive lion-tailed macaque groups housed outside India and those housed in Indian zoos

A significantly greater number of Indian zoos reported housing lion-tailed macaques that exhibit abnormal behaviour compared to zoos outside India ($U = 138.0$, $N = 24$ and 18, $P < 0.05$). These behaviours are shown in Figure 3.2. Foraging was reported to be exhibited by lion-tailed macaques housed in a significantly greater number of zoos outside India (95.8%) in comparison to reports from Indian zoos (44%; $U = 105.0$, $P < 0.001$).

Figure 3.3 Diets for lion-tailed macaques from zoos worldwide



3.5.3. Nutrition and diet of captive lion-tailed macaques

A significant percentage of the zoos outside India used commercial primate feed and supplemented these diets with insects while none of the Indian zoos fed commercial primate feed (Figure 3.3, total diet (includes all items fed to the study animals): $U = 85.5$, $N = 24$ and 18, $P < 0.001$; commercial primate feed: $U = 45.0$, $P < 0.001$; insects: $U = 81.0$, $P < 0.001$). There was no significant difference in the percentage of zoos outside India and Indian zoos that fed their lion-tailed macaques with meat, eggs, fruits and vegetables.

3.5.4. Visitor interaction with captive lion-tailed macaques

A significantly higher percentage of Indian zoos reported visitors feeding and interacting with lion-tailed macaques than did zoos outside India (Figure 3.4, total visitor disturbance: $U = 45.0$, $N = 24$ and 18, $P < 0.001$; visitor interaction: $U = 84.0$, $P < 0.001$; visitor feeding: $U = 66.0$, $P < 0.001$).

Figure 3.4 Visitor interaction with lion-tailed macaques housed in zoos worldwide

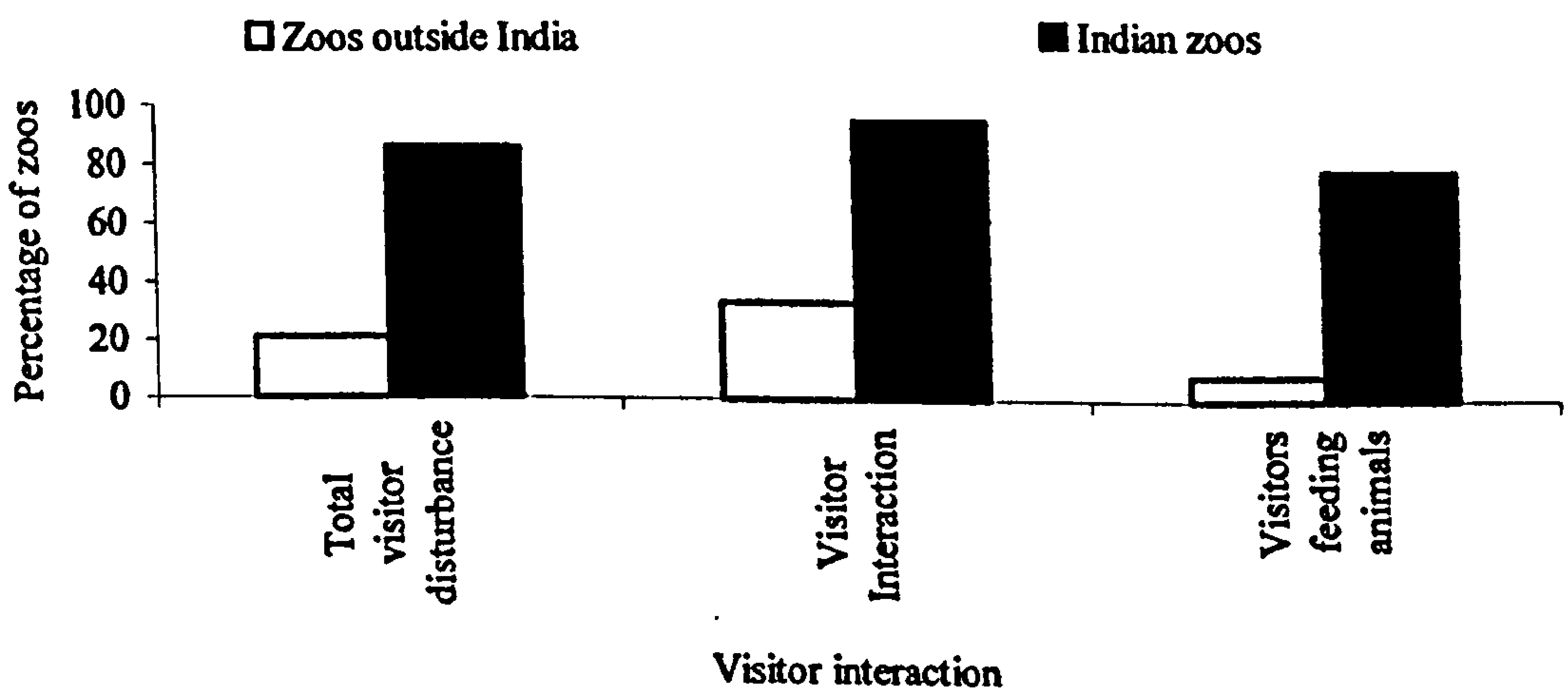
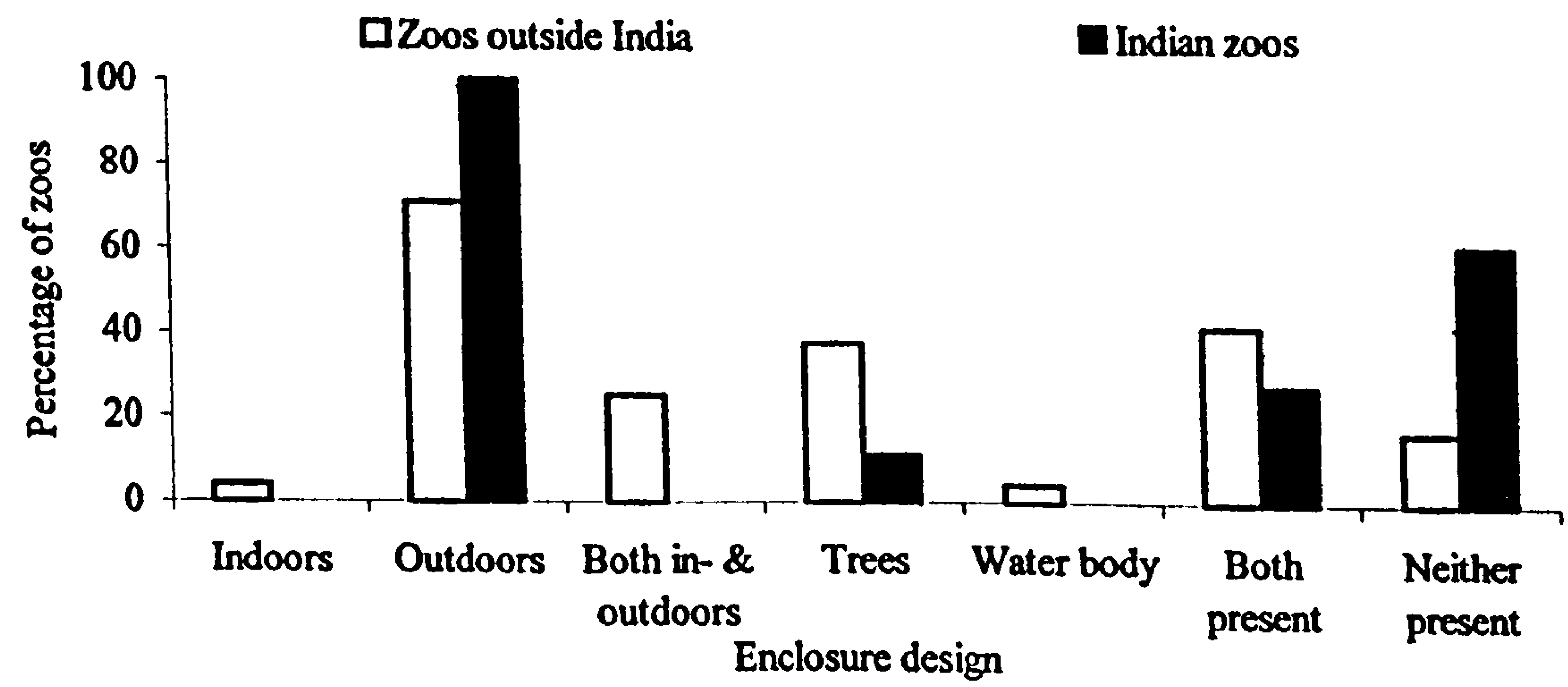


Figure 3.5 Design of enclosures housing lion-tailed macaques in zoos worldwide



3.5.5. Lion-tailed macaque exhibit design

Of the zoos outside India, 70.8% reported that they housed their captive lion-tailed macaques in enclosures greater than 45 m^2 in floor area per group, while only 33.3% of the Indian zoos did so. Significantly more zoos outside India maintained their animals in either indoor or outdoor exhibits than did those in India (Figure 3.5, $U = 72.0$, $N = 24$ and 18, $P < 0.001$). Trees and water bodies were included in a greater percentage of macaque exhibits in zoos outside India compared to those in India (Plate 3.1, $U = 120.0$, $P < 0.005$). Finally, a significantly greater percentage of zoos outside India administered enrichment to the macaque enclosures (Figure 3.6 & Plate 3.2, $U = 18.0$, $P < 0.001$). The types of structural and feeding enrichment used by the zoos outside India have been listed in Table 3.2.

Table 3.2 Types of enrichment administered to captive lion-tailed macaques in zoos outside India

Structural Enrichment	Feeding Enrichment
Paper bags and boxes	Sunflower seeds
Cardboard rolls	Insects and mealworm
Boomer balls	Monkey puzzles
Tree trunks and branches	Pinecones
Wooden benches	Wire baskets with peanuts
Leaves and bamboo	Raisins
PVC feeding tubes	Cardboard boxes with treats
Foraging toys	Icicles
Swings	Ice pops
Ropes	Popcorn
Tyres	Puzzle feeders
Bedding	Feeder boards
Hay or woodchips	Hanging cage feeders
Wood wool	Frozen juice cups
Nets and hammocks	Coconuts
	Dried fruits
	Food dispensers
	Food hiding
	Gum sticks

Figure 3.6 Frequency of enrichment administration in zoos worldwide

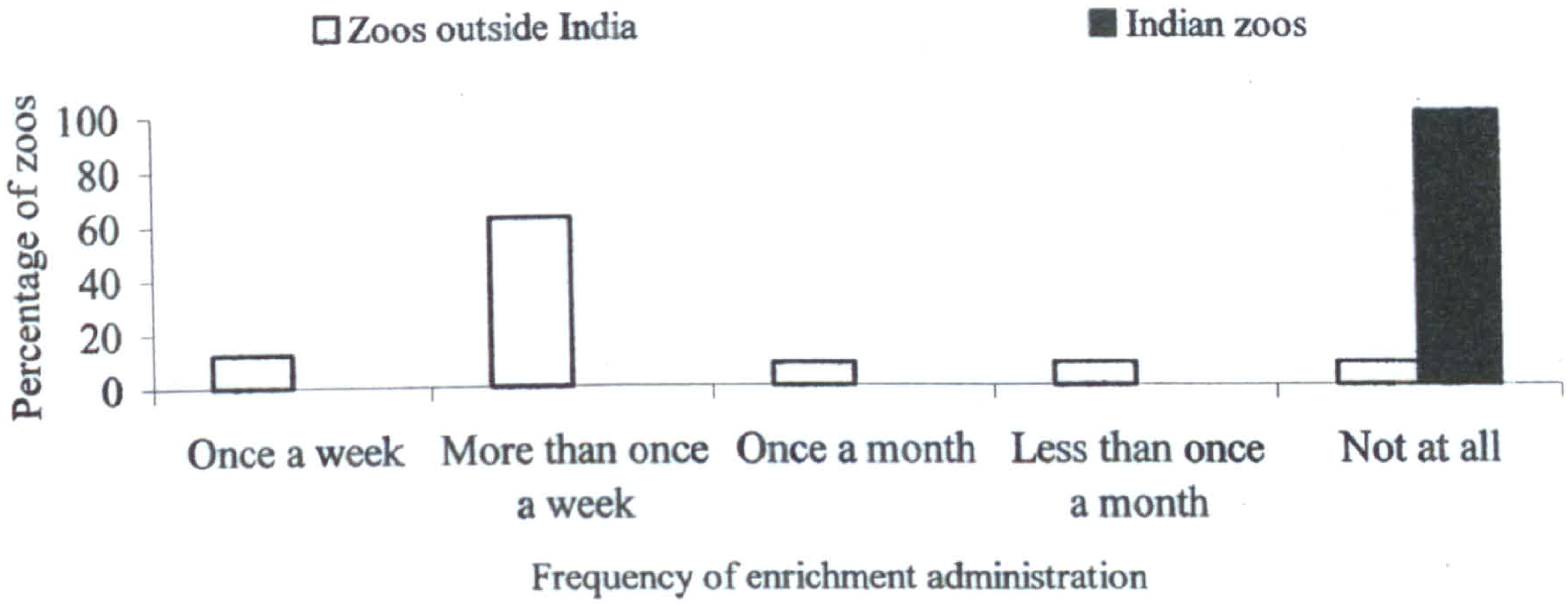


Plate 3.1 Outdoor enclosure housing lion-tailed macaques at Chester Zoo [Courtesy to Gilly Irving-Lewis]

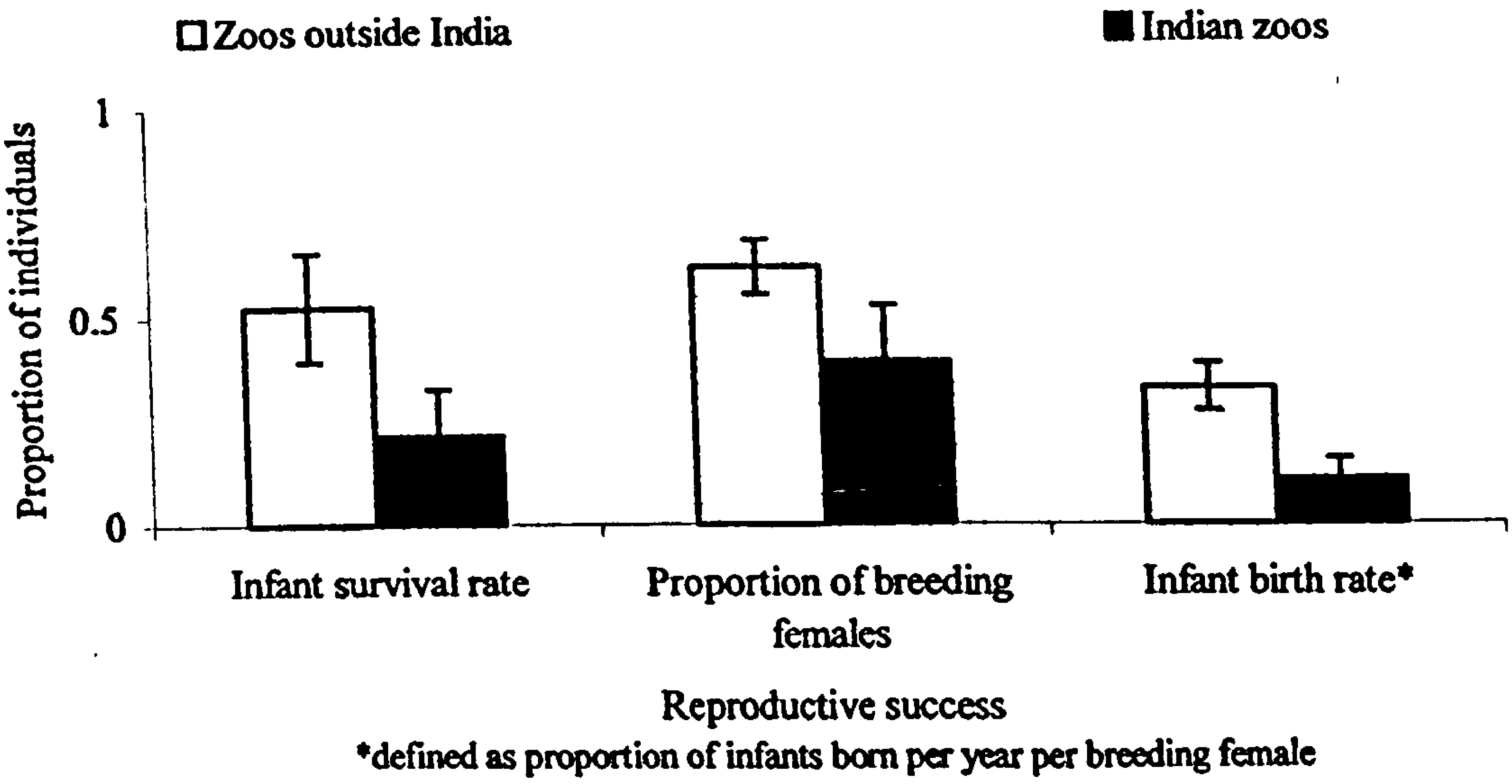
Plate 3.2 Outdoor enclosure for lion-tailed macaques with foraging device at Bristol Zoo [Courtesy to Gilly Irving-Lewis]

3.5.6. Reproductive success of captive lion-tailed macaque groups

Lion-tailed macaques have bred in a significantly greater proportion of zoos outside India over the past five years than in India ($U = 47.0$, $N = 17$ (macaques housed in pairs/ groups in zoos outside India) and 12 (macaques housed in pairs/ groups in Indian zoos), $P < 0.05$). In addition, none of the Indian zoos form part of any organised breeding programme, while 91.67% of the international zoos participate in specific regional lion-tailed macaque breeding programmes ($U = 11.0$, $P < 0.0001$).

A greater proportion of females have bred over the past five years and infant survival rates were significantly higher in zoos outside India in comparison to those in India (Figure 3.7, breeding females: $U = 73.5$, $N = 17$ and 12, $P < 0.05$; infant survival rate: $U = 49.0$, $P < 0.005$). The infant birth rate (proportion of infants born per breeding female per year) in zoos outside India was also higher than that in Indian zoos ($U = 56.5$, $P < 0.001$).

Figure 3.7 Reproductive success of captive lion-tailed macaques housed in zoos wolrdwide



3.6. DISCUSSION

3.6.1. Introduction

The questionnaire survey on the husbandry and management of lion-tailed macaques in zoos outside India revealed that a high percentage (71.4%) of countries whose zoos did not reply to the survey were from Asia, while 85% of the zoos that did reply were from developed countries. Over the last three decades, a considerable percentage of basic and applied research has been conducted in zoos; this has led to advances in captive wild animal management techniques and finally the recreation of the modern zoo (Maple *et al* 1995). A significant proportion of these research initiatives are conducted in zoos in North America, Australia and in Europe, and this probably explains these zoos' willingness to take part in surveys such as this. A lack of participation from Asian zoos could probably be attributed to lingual diversity and difficulty in English language comprehension and inexperience from not having participated in similar surveys in the past.

3.6.2. Demography of captive lion-tailed macaque populations

In the wild, lion-tailed macaques usually live in multi-female groups of 8 to 40 individuals with only 1-3 adult males (Kumar 1995; Raghavan 2001). Lion-tailed macaques are housed in 18 Indian zoos and in 60 zoos elsewhere around the world. International zoos house a greater number of macaque individuals per zoo, which in turn allows these zoos to maintain most of the individuals in species-appropriate group compositions. Also, since several of these zoos keep lion-tailed macaques in large groups consisting of one or more males with several females and their young, the probability of having to house surplus males at each facility is greatly reduced. In Indian zoos, however, the low numbers of individuals in each zoo has led to almost half the Indian population being housed in isolation, a condition most inappropriate for a social primate species. Some Indian zoos maintain groups consisting of one male, several females with infants, juveniles and/or subadults, as are commonly seen in the wild. This nevertheless often leads to a surplus of males in the Indian captive population; such males are housed in isolation. Finally, regulations against single-housing for social animals has made it imperative to house all non-human primates in pairs, if not in groups in captive facilities outside India (for example DETR 2000). However, lion-tailed macaques do not usually form all-male troops in the wild; behavioural studies are therefore needed on such associations in international zoos to determine the welfare implications of this kind of grouping.

3.6.3. Behavioural differences in the captive lion-tailed macaque populations

Housing non-human primates such as these in isolation could compromise their welfare and influence the development of stress-related pathologies such as abnormal behaviours (Erwin & Deni 1979; Anderson & Chamove 1980, 1985; Rendall & Taylor 1991; Mallapur & Choudhury 2003). It may also stimulate the exhibition of abnormalities such as self-mutilatory behaviour, self-clasping, masturbation, re-ingestion, regurgitation, coprophagy, stereotypic pacing and an inability to breed (Erwin & Deni 1979; Rendall & Taylor 1991; Reinhardt 1997; Mallapur & Choudhury 2003). Some of the abnormal behaviours exhibited by lion-tailed macaques in zoos outside India were hair plucking, stereotypic pacing, saluting and homosexual behaviours. In Indian zoos, the captive lion-tailed macaque population exhibited a more diverse group of behavioural pathologies that included stereotypic pacing, hair plucking, begging, excessive aggression, nipple licking, regurgitation and re-ingestion, self biting, floating limb, head tossing, head shaking, bouncing and auto-erotic stimulation (see Chapter IV). Begging has also been documented in an earlier study on captive lion-tailed macaques in Indian zoos; individuals housed in isolation in small barren enclosures with short visitor distances exhibited the highest frequencies of begging compared to individuals housed in large open-moated enclosures having greater visitor distances (Mallapur & Choudhury 2003).

3.6.4. Exhibit design

Enclosure design could also influence behaviour (for example Clarke *et al* 1982; Goerke *et al* 1987; Macedonia 1987; O'Neill *et al* 1991; Reinhardt *et al* 1996). In the questionnaire survey, a large number of zoos outside India, for example, documented lion-tailed macaques foraging in their facilities. This could be due to the fact that a large percentage of zoos outside India had water bodies and trees included within their macaque exhibits. A surplus supply of leaves, young shoots, flowers and fruits could stimulate a primate to forage. Similarly, a water body is an ideal area to forage for insects, as they congregate and hover above the water surface. Free-ranging lion-tailed macaques spend approximately 22 to 24% of their foraging time in the trees in their natural habitats (Kumar 1995; Raghavan 2001). In India, 60% of the zoos housed their lion-tailed macaques in enclosures without trees or water bodies. This could account for why only 44% of Indian zoos observed their macaques foraging.

3.6.5. Administration of environmental enrichment

Administering enrichment could also influence levels of abnormal and foraging behaviour (for example Estep & Baker 1991; Zucker *et al* 1991; Kessel & Brent 1996). Most of the zoos outside India regularly administered enrichment to their lion-tailed macaques; while none of the Indian zoos did so. Zoos outside India also used various techniques such as the addition of branches, logs, ropes and swings to give the macaques the opportunity to exhibit a wider range of behavioural patterns. Free-ranging lion-tailed macaques spend approximately 53% of their time feeding or foraging in the wild (Raghavan 2001). The lack of appropriate food-related stimuli could, result in a displacement of behavioural patterns leading to animals exhibiting enhanced levels of abnormal behaviours. Feeding enrichment has been documented to increase the percentage of foraging and exploratory behaviours exhibited by captive animals (for example Reinhardt 1993; Buchanan-Smith 1995; Steen 1995; Ludes & Anderson 1996; Zimmerman & Feistner 1996; Ludes-Faulab & Anderson 1999). Zoos outside India have, therefore, infused feeding enrichment techniques such as scatter feeding, puzzle feeders, hiding feed and hanging feed in to daily animal feeding routines to provide their animals with appropriate stimuli to encourage a more natural behavioural repertoire. Feeding enrichment is usually directly associated with food preparation, diets, and nutrition at most zoos. Dietary choice and presentation are also significant in mimicking the animal's natural environment and stimulating the exhibition of exploratory and foraging behaviours (Allen & Oftedal 1996).

3.6.6. Nutrition and diets of captive lion-tailed macaques

In zoos, diets are carefully prepared depending on the calorie intake and nutrient requirement of each individual, which are calculated according to its body weight and several other factors such as age and general health (Allen & Oftedal 1996). Zoos outside India predominantly feed lion-tailed macaques on regulated quantities of commercial primate pellet, which is periodically supplemented with insects/ mealworms, eggs and other forms of feeding enrichment. India, being a tropical country, has the advantage of being able to obtain fresh fruits, greens and vegetables on a daily basis to feed their primates. A diet such as this would be ideal if the quantities fed per individual per day were regulated and also supplemented with eggs, insects and minerals. Improperly prepared diets could, compromise the welfare of captive lion-tailed macaques in many Indian zoos. Obesity, for example, has been recorded in several species at many zoos (*pers. obs.*).

3.6.7. Visitor-interaction

In India, obesity in captive non-human primates is also influenced by feeding by visitors. A large percentage of Indian zoos recorded visitors interacting and feeding their lion-tailed macaques. Studies have shown that visitor disturbance can adversely influence a captive animal's welfare (for example Chamove *et al* 1988; Mitchell *et al* 1991; Venugopal & Sha 1993). In addition, visitor interaction could also cause deficiencies, nutritional toxicity and/ or a higher calorific intake since feeding by visitors is usually uncontrolled.

Factors such as enclosure design, visitor disturbance, nutrition, group composition and enrichment have been documented in literature to influence behaviour and welfare of captive animals; this, in turn, influences their reproductive success (Kleiman *et al* 1991; Lindburg & Gledhill 1992; Lindburg & Harvey 1996; Lindburg *et al* 1997). In Indian zoos, lion-tailed macaques are predominantly housed in barren enclosures, kept in isolation or in pairs, fed imbalanced diets, and often subjected to high levels of visitor disturbance. These could be the reasons why most macaque females in these zoos do not breed and also exhibit low infant birth and survival rates. The problems of macaque husbandry in Indian zoos is further emphasised by the relatively high percentage of Indian zoos (60%) that have reported behavioural pathologies exhibited by the individuals housed in their facilities.

3.7. CONCLUSIONS

Attempts are currently underway to investigate the influence of these factors on the behaviour and welfare of captive lion-tailed macaques in several Indian zoos. In order to improve husbandry and management practices followed in Indian zoos, further studies on the factors that influence the behaviour and welfare of captive lion-tailed macaques should be carried out, and behavioural monitoring of all captive individuals needs to be conducted regularly.

CHAPTER IV *Behavioural Survey*

CONTENTS

Factors Influencing the Behaviour and Space Use of Captive Lion-Tailed Macaques (*Macaca silenus*) in Indian Zoos

4.1. ABSTRACT

A behavioural study was conducted on 51 lion-tailed macaques housed in 13 zoos across India. An ethogram was constructed and behavioural observations conducted using sampling *ad libitum*, focal animal sampling and instantaneous scans. Sampling was carried out only during the days when visitors were present at the macaque enclosures. Stereotypic pacing was the most commonly exhibited behaviour. Abnormal behaviours were only exhibited by individuals confiscated from private owners and individuals born in zoos but never by those born in the wild. Active foraging behaviours, in turn, were influenced by an individual's gender and enclosure complexity. Female macaques, autogroomed and lip-smacked more frequently than males, while individuals housed in groups initiated relatively more allogrooming than those housed in pairs. Space utilisation by each individual was recorded during instantaneous scans. Captive lion-tailed macaques were observed to use the area closest to visitors the most, as compared to any other area in the enclosure. The performance of abnormal behaviours was positively correlated, while food-related behaviours and social interactions were negatively correlated to the use of the enclosure area closest to visitors. Animals housed in barren enclosures used this area to a significantly greater percentage than those housed in complex exhibits. The performance of grooming, social interactions and food-related behaviours were positively correlated with the use of those enclosure areas which had trees, shrubs and/ or water points. In general, the observed influence of environmental factors and social deprivation on the development of behavioural abnormalities in lion-tailed macaques in Indian zoos emphasise the need for improving the current husbandry protocols and management practices for the improved welfare of these animals.

Key words: zoo, lion-tailed macaque, abnormal behaviour, animal welfare, enclosure design, group composition

4.2. INTRODUCTION

Most zoos of the world house non-human primates, a group of highly diverse species that is popular with the visiting public (Hanson 2002). Humans are drawn to primates because of their intelligence and the behaviour patterns they display. Primates, like other animals, exhibit complex sequences of behaviour and depend on their environment for cues to stimulate them to display these patterns (Maple *et al* 1995). In atypical environments such as small, barren enclosures in zoos, these environmental stimuli usually are absent leading to the development of unusual behavioural patterns that are usually not exhibited by free-ranging primates (Erwin & Deni 1979). These behaviours are referred to as "abnormal behaviours" or "behavioural abnormalities" (Carlstead 1996; Duncan & Fraser 2000).

In order to monitor and to examine the degree of variance in the behaviours primates display in captivity and also to compare these behavioural patterns with those exhibited by their free-ranging counter-parts, an ethogram is sometimes designed (for example Nickelson & Lockard 1978; Hearn *et al* 1986, 1988; Mallapur *et al* in press). Ethograms such as these have also been used for several other purposes; for example those designed for free-ranging primates, document the basic behavioural biology of the species (Martinic 1990; dos Santos *et al* 1997; Sugiyama 1998; Raghavan 2001). These studies provide new invaluable information on behaviour, which can be used to understand the basic biology of the species. Some studies have used ethograms to compare between the behaviours exhibited by breeding and non-breeding groups of captive primates to document social and reproductive behavioural differences in order to be able to improve the success of conservation breeding programmes (Nickelson & Lockard 1978; Hearn *et al* 1986, 1988; Johnson 1985; Mallapur *et al* in press).

Scientists have also recognised that documenting animal behaviour is the first step towards understanding them in relation to their environment. In recent years, behavioural monitoring has been included in the management and husbandry protocols of some modern zoos (Carlstead 1998). It is believed that husbandry-related behaviour problems could be influenced by personality differences. Hence, zoos also monitor behaviour in order to document individual animal behavioural profiles (Carlstead 1998; Wielebknowski 1999).

In this study on captive lion-tailed macaques, an ethogram was designed to be able to clearly define all the abnormal behaviours exhibited by the species in captivity, to study the differences in social and reproductive behaviour between breeding and non-breeding groups and also to examine the diversity of natural behaviours exhibited in comparison with free-ranging individuals.

4.3. AIM

The aim of this study was:

1. To construct a detailed ethogram of lion-tailed macaque behaviour in captivity and to measure the durations and frequencies of the observed behaviours
2. To identify and study the influence of factors such as enclosure design, rearing history, group composition, and feeding time on the behaviour and welfare of captive lion-tailed macaques
3. To document the use of available space by lion-tailed macaques housed in Indian zoos. The purpose of recording space use was to recognise areas within the enclosure, which are actively used by the captive macaques and to identify possible reasons why any areas were not utilised

4.4. METHODS

4.4.1. General Methods

The behavioural study was conducted on 51 of the available 53 captive lion-tailed macaques housed in 13 zoos across India (refer to Table 2.1 in Chapter II *General Methods*). The feeding time and the time at which the animal keepers cleaned the enclosures varied across zoos (refer to feeding and keeper cleaning schedules in Table 2.2 and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*). The diet charts also varied considerably across zoos as well (refer to diet charts Table 2.3

Table 4.1. List of behaviours exhibited by captive lion-tailed macaques housed in Indian zoos (refer to Appendix 4.1 for definitions of behaviour

A. BEHAVIOURAL STATES
1. ABNORMAL BEHAVIOURS
1.1 Qualitative behavioural pathologies
1.1.1. Self-directed behaviours
a. Novel behavioural pathologies
- i. Circle repetitively
- ii. Floating limb
- iii. Pluck hair
- iv. Stereotypic pacing

b. Behavioural interchanges
- i. Self-biting

1.1.2. Social interactions
a. Novel behavioural pathologies
- i. Beg

2. NORMAL BEHAVIOURS
2.1. Self-directed behaviours
2.1.1. Active behaviours
- i. Climb
- ii. Run
- iii. Walk

2.1.2. Rest behaviours
- i. Lying down
- ii. Sit
- iii. Sleep
- iv. Stand

2.1.3. Food-related behaviours
- i. Feed
- ii. Forage – active
- iii. Forage – passive

2.1.4. Autogroom

2.2. Social interactions
- i. Allogroom
- ii. Mate
- iii. Play
- iv. Suckle

B. BEHAVIOURAL EVENTS
1. ABNORMAL BEHAVIOURS
1.1. Qualitative behavioural pathologies
1.1.1. Self-directed behaviours
a. Novel behavioural pathologies
- i. Bounce
- ii. Circle Repetitively
- iii. Floating limb
- iv. Head-toss
- v. Oral stereotypy
- vi. Pluck hair
- vii. Regurgitate and re-ingest
- viii. Rock
- ix. Rub or lick nipple
- x. Run with head up
- xi. Salute
- xii. Stereotypic pacing
- xiii. Telescoping
- xiv. Weave

a. Behavioural interchanges
- i. Affiliative bared-teeth face
- ii. Affiliative grunt
- iii. Bared-teeth display
- iv. Eye-flash
- v. Self-biting
- vi. Warning growl

1.1.2. Social interactions
a. Novel behavioural pathologies
- i. Beg
- ii. Body-shake with lip-smack
- iii. Hold penis
- iv. Splash water

b. Behavioural interchanges
- i. Auto-erotic stimulation

1.2. Quantitative behavioural pathologies
1.2.1. Self-directed behaviours
- i. Branch shake or display bounce
- ii. Inspect penis
- iii. Masturbate
- iv. Scratch body
- v. Yawn
- vi. Autogroom

1.2.2. Social interactions
- i. Affiliative bared-teeth face
- ii. Bared-teeth display
- iii. Eye-flash

2. NORMAL BEHAVIOURS
2.1. Self -directed behaviours
- i. Alarm call
- ii. Autogroom
- iii. Bipedal alert
- iv. Body-shake
- v. Cough
- vi. Defecate
- vii. Drink
- viii. Ejaculate and lick semen
- ix. Hiccup
- x. Inspect penis
- xi. Jump
- xii. Lick hand
- xiii. Lick object
- xiv. Masturbate
- xv. Scan
- xvi. Scratch body
- xvii. Sneeze
- xviii. Stretch
- xix. Swing or brachiate
- xx. Swipe at insect
- xxi. Urinate
- xxii. Wipe mouth or nose
- xxiii. Yawn

2.2. Social interactions
2.2.1. Affiliative behaviours
- i. Affiliative bared-teeth face
- ii. Affiliative grunt
- iii. Contact call
- iv. Follow
- v. Hold
- vi. Mouth-touch
- vii. Touch

2.2.2. Reproductive behaviours
- i. Attempted mount
- ii. Avoid mount
- iii. Copulatory call
- iv. Copulatory grimace
- v. Inspect
- vi. Move away
- vii. Present
- viii. Scream
- ix. Simple mount
- x. Staccato call
- xi. Thrust mount

2.2.3. Aggressive behaviours
- i. Aggressive bark
- ii. Aggressive bite
- iii. Bared-teeth display
- iv. Branch shake or display bounce
- v. Chasing
- vi. Crouch
- vii. Fear grimace
- viii. Fear scream
- ix. Flee
- x. Lunge
- xi. Pull roughly
- xii. Push away
- xiii. Warning growl

2.2.4. Infant-related behaviours
- i. Groom infant
- ii. Hold infant
- iii. Pull infant
- iv. Push infant
- v. Touch infant

2.2.5. Neutral behaviours
- i. Alert
- ii. Allogroom
- iii. Approach
- iv. Avoid
- v. Ignore
- vi. Lipsmacking
- vii. Lost call
- viii. Retreat

2.2.6. Play behaviours
- i. Play bite
- ii. Play chase
- iii. Play fight
- iv. Play jump
- v. Play slap

and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*). Observations for this study were conducted between June 2002 and October 2003.

4.4.2. Preparation of the ethogram

At each zoo, all individuals that were exhibited to the public were studied. Behaviour was sampled *ad libitum* to develop an ethogram (refer to Table 4.1 & Appendix 4.1).

4.4.3. Behavioural sampling

During the study, a combination of focal animal sampling and instantaneous scanning was used to quantify the behaviour displayed by the captive macaques (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). In each zoo, all macaques were observed for a period of a mean (± SE) of 5.4 ± 0.03 h (N = 51) and a total of 278.9 hours were spent observing these animals across the 13 zoos. All individuals that were exhibited to the public were studied for a period of nine hours during the day between 0830 h, when the zoo opened in the morning and 1730 h, when it closed for the day. Each behavioural sampling session was initiated with an instantaneous scan, and was followed by a focal animal sample of one of the individuals in the group for a duration of 15 min (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). The study period could range from seven to 10 days (for one group) in some places. The time spent at each zoo usually depended on the number of lion-tailed macaques housed in that group.

4.4.3. Space use

The use of enclosure space by captive lion-tailed macaques was recorded during the instantaneous scans conducted to record the behavioural states (refer to Section 2.3 *Space Use* in Chapter II *General Methods*).

4.4.4. Data analyses

Behaviour and space use data for different individuals in each group were pooled at the end of the observation period to obtain group averages (refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). Hence, data for 51 individuals were pooled to obtain 26 groups. The data were analysed using the Friedman's two-way analysis of variance by ranks test (FV) for multiple comparisons of similar groups and the Kruskal-Wallis one-way analysis of variance by ranks test (KW) for multiple comparisons (three or more samples) of independent groups (Siegel & Castellan 1988; for more information on tests, refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). On obtaining significant results for both the FV and KW tests, post-hoc analysis was conducted to identify individual pairs that were significantly different. Mann-Whitney U-Test (U) was used to analyse differences between two independent samples (Siegel & Castellan 1988; for more information on tests, refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). Since several factors seemed to influence behaviour simultaneously, partial correlations (PC) were conducted to determine the individual influence of competing factors on the performance of specific behaviours (Siegel & Castellan 1988; refer to ranks in Table 2.5 and Section 2.4 *Data Analyses* in Chapter II *General Methods*). Spearman's rank-order correlation (SPT) was conducted to test if their was any association between percentage behaviour exhibited and percentage time spent in each enclosure zone (Siegel & Castellan 1988; for more information on tests, refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). All sample sizes mentioned in the text refer to lion-tailed macaques groups and not individuals. P values that have been reported are two-tailed. SPSS (Version 7.5) was used to conduct the statistical analyses.

4.5. RESULTS

4.5.1. Ethogram

Twenty behavioural states and 106 behavioural events were found to be exhibited by captive lion-tailed macaques housed in Indian zoos (refer to Table 4.1 & Appendix 4.1). Of the 20 behavioural states, six were identified as abnormal behaviours (for definitions of behaviours, refer to Appendix 4.1). The 14 normal behaviours were classified as; active behaviours, rest-related behaviours, food-related behaviours, autogrooming and social interactions (refer to Table 4.1 & Appendix 4.1). The behavioural events consisted of 34 abnormal behaviours and 72 normal behaviours (refer to Table 4.1 & Appendix 4.1).

4.5.2. Differences in behaviour exhibited

There were significant differences in the mean percentage of time spent in different behavioural states, including active behaviours, rest-related behaviours, autogrooming, social interactions, food-related behaviours and abnormal behaviours, by all the 51 study individuals in 26 groups across the 13 zoos. The greatest percentage of time was dedicated to rest-related behaviours (45.7 ± 2.9%) as compared with active behaviours (25.0 ± 1.8%), food-related behaviours (14.8 ± 1.7%), abnormal behaviours (7.7 ± 2.0%), autogrooming (3.5 ± 0.8%), and social interactions (3.0 ± 1.1%) (Friedman's Test, $\chi^2 = 115.52$, df = 6, $P < 0.0001$, N = 26; for post-hoc analysis refer to Table A1. in Appendix 4.2).

4.5.2.1. Abnormal behaviours

The study individuals were observed exhibiting several types of abnormal behaviours, of which six could be considered as behavioural states and 34 as behavioural events (listed in Table 4.1). Stereotypic pacing also exhibited to greatest proportion (mean ± SE of 15.6 ± 2.9%, N = 14) in comparison to the other abnormal behaviours displayed (Begging, 4.5 ± 1.7%, N = 6; floating limb, 4.3 ± 1.3%, N = 7; self-biting, 0.9%, N = 1; hair-plucking, 0.9%, N = 1; Table 4.2).

Table 4.2. Abnormal behavioural states (S) and events (E) exhibited by different categories of study animals. Behavioural states have been measured as percentage of observed time spent in those behaviours and behavioural events as number of events per hour. The mean ± standard error and number of individuals (N) exhibiting particular behaviours are shown

Behaviour	Confiscated animals	Zoo-born animals
Beg (S)[1]	10.9 ± 2.7, N[2] = 2	4.8 ± 1.2, N = 4
Beg (E)[3]	2.05 ± 1.0, N = 6	4.0 ± 1.06, N = 7
Floating limb (S)	4.4 ± 1.7, N = 6	1.2, N = 1
Floating limb (E)	3.1 ± 1.7, N = 5	0.0
Pluck hair (S)	0.0	0.4, N = 1
Pluck hair (E)	0.0	1.0 ± 0.5, N = 2
Self-biting (S)	0.9, N = 1	0.0
Self-biting (E)	0.5 ± 0.1, N = 6	2.1, N = 1
Stereotypic pacing (S)	14.6 ± 2.2, N = 11	6.7 ± 5.6, N = 3
Stereotypic pacing (E)	10.0 ± 2.8, N = 11	2.6 ± 2.4, N = 2
Bipedal walk with masturbation (E)	2.0, N = 1	0.0
Bite hand (E)	1.2 ± 0.3, N = 7	0.0
Bounce (E)	0.8 ± 0.4, N = 7	1.02 ± 0.2, N = 6
Head-toss (E)	5.7 ± 3.4, N = 6	0.0
Hold penis (E)	0.8 ± 0.5, N = 6	0.3, N = 1
Lick nipple (E)	3.3, N = 1	0.0
Masturbating – copulatory grimace (E)	0.6 ± 0.3, N = 3	0.0
Oral stereotypy (E)	3.7, N = 1	0.0
Regurgitate (E)	1.4 ± 0.8, N = 2	0.0
Re-ingest (E)	2.2, N = 1	0.0
Repetitive head and body-shaking (E)	6.4, N = 1	0.0
Self-directed affiliative bared-teeth face (E)	0.9 ± 0.4, N = 2	6.7 ± 13.05, N = 5
Self-directed affiliative grunt (E)	0.9 ± 0.4, N = 2	0.4 ± 0.6, N = 4
Self-directed bared-teeth face (E)	1.05 ± 08, N = 3	0.1 ± 0.1, N = 2
Self-directed eye-flash (E)	1.3 ± 1.9, N = 4	0.5 ± 0.5, N = 3
Self-directed warning growl (E)	3.3 ± 4.05, N = 9	0.05 ± 0.01, N = 3
Splash water (E)	2.4 ± 1.8, N = 3	0.0

[1] S = behaviour that were recorded as behavioural states. These have been represented as mean percentages of time ± standard error

[2] N represents the individuals exhibiting the behaviour in question.

[3] E = behaviour that were recorded as behavioural events. These have been represented as mean frequencies per hour ± standard error

i. Rearing history: Abnormal behaviours were only exhibited by confiscated (N = 20, refer Table 2.5 in Chapter II) and zoo-born individuals (N = 25), and never by any wild-caught (N = 1) and captive-reared animals (N = 1) during the course of the study (refer to Chapter II, *General Methods* for definitions of confiscated, zoo-born, wild-caught and captive-reared individuals). Of these abnormal behaviours, self-directed behaviours such as floating limb, self-biting, head-toss and certain types of self-stimulatory behaviours including bipedal walk with masturbation, masturbating with copulatory grimace, rubbing or licking nipple and holding penis, were exhibited only by confiscated animals and almost never by zoo-born individuals (Table 4.2).

Table 4.3. Partial correlations of the performance of abnormal behavioural states (S) and events (E) to different individual characteristics and captivity factors

Correlation	Correlation coefficient	P value	Constant factor
Abnormal behaviour (S) – rearing history	0.4364	0.029	Enclosure substrate
Abnormal behaviour (S) – rearing history	0.4291	0.032	Enclosure type
Abnormal behaviour (S) – rearing history	0.3922	0.050	Enclosure complexity
Stereotypic pacing (S) – rearing history	0.4783	0.016	Enclosure substrate
Stereotypic pacing (S) – rearing history	0.3916	0.053	Feeding regime
Stereotypic pacing (S) – rearing history	0.4115	0.041	Zoo category
Head toss (E) – rearing history	0.4298	0.036	Feeding regime
Head toss (E) – rearing history	0.4739	0.019	Enclosure complexity
Head toss (E) – rearing history	0.4380	0.032	Housing

ii. Factors that influence abnormal behaviour: In order to determine whether abnormal behaviours exhibited by the study animals were influenced by particular individual characteristics, and/ or captivity factors, partial correlations were conducted (Table 4.3). Due to the low number of individuals performing certain abnormal behaviours, it was not possible to test the influence of all factors on the amount of behaviours such as begging and floating limb exhibited. The percentage of total abnormal behaviours as well as the percentage of observation time spent in stereotypic pacing, did however, correlate with rearing history when corrected for enclosure substrate (Total abnormal behaviour, Partial Correlations (PC), $\rho = 0.4364$, $P < 0.05$, $N = 26$; stereotypic pacing, $\rho = 0.4783$, $P < 0.05$; for other partial correlations, refer to Table 4.3). Thus, individuals that were confiscated paced more and performed significantly higher levels of total abnormal behaviour than zoo-born animals (total abnormal behaviours: $U = 41.500$, $N = 11$ (zoo-born groups) and 14 (confiscated groups), $P \leq 0.05$; stereotypic pacing: $U = 39.000$, $P < 0.05$). Of all the individuals that exhibited stereotypic pacing, 92.3% were housed in cages (17.9 ± 1.1%, N = 12) while the rest were in moated enclosures (wet moated: 1.79%, N = 1; dry moated: 0.79%, N = 1).

Confiscated animals also tended to exhibit a significantly greater percentage of total abnormal behaviour than did any other class of rearing history.

Table 4.4. Partial correlations of the performance of active and resting behavioural states (S) and events (E) to different individual characteristics and captivity factors

Correlation	Correlation coefficient	P value	Constant factor
Climb (S) – rearing history	-0.4240	0.035	Enclosure size
Stand (S) – rearing history	0.4248	0.034	Sex
Stand (S) – rearing history	0.5518	0.004	Vertical access
Stand (S) – rearing history	0.4864	0.014	Enclosure complexity
Walk (S) – zoo type	0.4698	0.018	Sex
Walk (S) – zoo type	0.5005	0.011	Enclosure size
Walk (S) – sex	0.4409	0.027	Enclosure type
Walk (S) – sex	0.4085	0.043	Zoo type
Yawning (E) – vertical access	-0.4317	0.035	Enclosure complexity
Yawning (E) – vertical access	-0.5345	0.007	Housing
Yawning (E) – vertical access	-0.5942	0.002	Rearing history

4.5.2.2. Active and rest-related behaviours

Partial correlations between active and resting behavioural states and events and different individual characteristics and captivity factors are shown in Table 4.4. Rearing history positively correlated with standing and negatively with climbing behaviours (corrected for enclosure size, climb, $\rho = -0.4240$, $P < 0.05$; corrected for enclosure complexity; stand, $\rho = 0.4864$, $P < 0.05$; for other partial correlations, refer to Table 4.4). Confiscated animals thus stood more and climbed less than did zoo-born individuals (Kruskal-Wallis test (KW), climb, $\chi^2 = 6.54$, df = 3, $P < 0.05$, N = 1 (captive-reared), 11 (zoo-born), 14 (confiscated); stand, $\chi^2 = 7.14$, $P < 0.05$; for post-hoc pair-wise comparison, refer to Table A2. in Appendix 4.2; Plate 4.1). Animals housed in zoos within cities exhibited lower levels of walking than those housed in zoos outside the city-limits, while females walked significantly more than did males (corrected for gender, influence of zoo type, $\rho = 0.4698$, $P < 0.05$; U = 35.000, N = 13 (zoos outside the city) and 13 (zoos inside the city), $P < 0.05$; corrected for zoo type, influence of gender, $\rho = 0.4085$, $P < 0.05$; U = 36.000, N = 13 (males) and 13 (females), $P < 0.05$).

Plate 4.1 Female lion-tailed macaque at Thiruvananthapuram Zoo scanning the surrounding area from a small tree

The frequency of yawning exhibited in enclosures having a vertical access was significantly lower than that in enclosures with no vertical access (corrected for enclosure complexity, $\rho = -0.4317$, $P < 0.05$). Rearing history was correlated with coughing (corrected for enclosure complexity, $\rho = -0.5870$, $P < 0.005$), captive-reared individuals coughed more than confiscated animals (KW, $\chi^2 = 6.54$, df = 2, $P < 0.05$, N = 1 (captive-reared), 11 (zoo-born), 14 (confiscated); for post-hoc pair-wise comparison, refer to Table A2. in Appendix 4.2). Captive-reared individuals also exhibited stretching (0.01 event/h, N = 1) while confiscated and zoo-born animals did not.

Table 4.5. Partial correlations of the performance of food-related behavioural states (S) and events (E) with different individual characteristics and captivity factors

Correlation	Correlation coefficient	P value	Constant factor
Active foraging (S) – enclosure complexity	0.6022	0.001	Rearing history
Active foraging (S) – enclosure complexity	0.5563	0.004	Enclosure size
Active foraging (S) – enclosure complexity	0.5446	0.005	Housing
Active foraging (S) – enclosure complexity	0.4693	0.018	Enclosure type
Active foraging (S)– sex	0.5826	0.002	Zoo category
Active foraging (S)– sex	0.6065	0.001	Enclosure substrate
Active foraging (S)– sex	0.5957	0.002	Vertical access
Active foraging (S)– sex	0.6385	0.001	Rearing history
Active foraging (S)– sex	0.6061	0.001	Enclosure size
Active foraging (S)– sex	0.6471	0.0001	Housing
Active foraging (S)– sex	0.4545	0.022	Enclosure complexity
Active foraging (S)– sex	0.577	0.003	Enclosure type
Passive foraging (S) – enclosure type	0.8723	0.0001	Enclosure size
Passive foraging (S) – enclosure type	0.8153	0.0001	Housing
Passive foraging (S) – enclosure type	0.7214	0.0001	Enclosure complexity
Passive foraging (S) – enclosure type	0.8348	0.0001	Zoo category
Passive foraging (S) – enclosure type	0.8180	0.0001	Sex
Passive foraging (S) – enclosure type	0.6485	0.0001	Enclosure substrate
Swipe insect (E) – enclosure substrate	0.4090	0.047	Enclosure complexity
Swipe insect (E) – enclosure substrate	0.5325	0.007	Rearing history
Swipe insect (E) – enclosure substrate	0.4136	0.045	Housing

4.5.2.3. Food-related behaviours

Table 4.5 displays the partial correlations between the performance of different food-related behaviours by the study macaques and their individual characteristics as well as captivity factors. Active foraging behaviour, for example, was correlated with an individual's gender and to its enclosure complexity. Females actively foraged more than did males (corrected for enclosure substrate, $\rho = 0.6065$, $P < 0.005$; for other partial correlations, refer to Table 4.5; $U = 9.000$, $N = 13$ and 13, $P < 0.001$). Individuals housed in complex enclosures exhibited significantly higher levels of active foraging than did those maintained in barren enclosures (corrected for enclosure type, $\rho = 0.4693$, $P < 0.05$; KW, $\chi^2 = 15.74$, $df = 2$, $N = 9$ (barren), 10 (barren-but-enriched), 7 (complex), $P < 0.001$; for post-hoc pair-wise comparisons, refer to Table A3. in Appendix 4.2). Lion-tailed macaques housed in open-moated (dry-moated and wet-moated) enclosures displayed significantly higher levels of passive foraging than did those housed in cages (corrected for enclosure size, $\rho = 0.6723$, $P \leq 0.0001$; KW, $\chi^2 = 24.29$, $df = 2$, $N = 19$ (cage), 5 (wet-moated), 2 (dry-moated), P < 0.001; for post-hoc pair-wise comparisons, refer to Table A3. in Appendix 4.2).

Table 4.6. Partial correlations of the performance of autogrooming and other social interactions to individual characteristics and captivity factors

Correlation	Correlation coefficient	P value	Constant factor
Auto-grooming – sex	0.4678	0.021	Zoo category
Auto-grooming – sex	0.6065	0.002	Housing
Auto-grooming – sex	0.5241	0.009	Rearing history
Auto-grooming – sex	0.5174	0.010	Enclosure complexity
Eye flash + bared-teeth – zoo type	-0.4919	0.015	Enclosure complexity
Eye flash + bared-teeth – zoo type	-0.4794	0.018	Housing
Eye flash + bared-teeth – zoo type	-0.5106	0.011	Rearing history
Ignore – enclosure size	0.4628	0.023	Housing
Ignore – enclosure size	0.4507	0.027	Enclosure type
Ignore – enclosure size	0.4989	0.013	Rearing history
Lipsmacking – sex	0.4801	0.018	Vertical access
Lipsmacking – sex	0.5276	0.008	Enclosure complexity
Lipsmacking – sex	0.5022	0.012	Housing
Lipsmacking – sex	0.5869	0.003	Rearing history
Move away – feeding regime	-0.5288	0.009	Housing
Move away – feeding regime	-0.5368	0.007	Enclosure type
Move away – feeding regime	-0.4783	0.018	Enclosure complexity
Move away – feeding regime	-0.6234	0.001	Rearing history
Olfactory inspection – housing	-0.4793	0.018	Feeding regime
Olfactory inspection – housing	-0.4697	0.021	Rearing history
Olfactory inspection – housing	-0.4727	0.020	Enclosure complexity
Present with lipsmacking – feeding regime	-0.4133	0.045	Enclosure size
Present with lipsmacking – feeding regime	-0.5585	0.005	Rearing history
Present with lipsmacking – feeding regime	-0.5039	0.012	Housing
Present with lipsmacking – feeding regime	-0.5142	0.010	Enclosure complexity
Total aggression – enclosure complexity	-0.5299	0.008	Zoo category
Total aggression – enclosure complexity	-0.4521	0.003	Vertical access
Total aggression – enclosure complexity	-0.5541	0.005	Rearing history

Individuals housed on a soft substrate such as soil searched for insects at significantly greater frequencies than those in enclosures with a hard substrate such as concrete or cement (corrected for enclosure complexity, $\rho = 0.4090$, $P < 0.05$; $U = 27.000$, $N = 17$ (hard substrate) and 8 (soft substrate), $P < 0.05$).

4.5.2.4. Autogrooming and other social interactions

Partial correlations between the display of autogrooming and other social interactions by the study animals, on one hand, and different individual characteristics and captivity factors, on the other, have been depicted in Table 4.6. Autogrooming correlated with the gender of the individual, with females autogrooming more than males (corrected for rearing history, $\rho = 0.5241$, $P < 0.01$; for other partial correlations refer to Table 4.8; $U = 23.000$, $N = 17$ (males) and 8 (females), $P < 0.01$). Females also lip-smacked more frequently than did males (corrected for enclosure complexity, $\rho = 0.5276$, $P < 0.01$; $U = 19.500$, $N = 17$ (males) and 8 (females), $P < 0.005$). Eye-flashing with bared-teeth face was more frequently exhibited by individuals housed in zoos inside cities than those that are outside (corrected for enclosure complexity, $\rho = -0.4919$, $P < 0.05$; $U = 38.000$, $N = 12$ (zoos inside cities) and 13 (zoos outside cities), $P < 0.05$); ignore, in contrast, was displayed more frequently by individuals housed in larger enclosures than those maintained in small ones (corrected for enclosure type, $\rho = 0.4507$, $P < 0.05$; KW, $\chi^2 = 9.33$, df = 3, N = 7 (<100 m^2 in size), 9 (100-200m^2), 4 (200-300m^2), 5 (> 300m^2), $P < 0.05$; for post-hoc pair-wise comparisons, refer to Table A4. in Appendix 4.2). Olfactory inspection was significantly exhibited at higher levels by males housed in groups than in any other type of group composition (corrected for enclosure complexity, $\rho = -0.4727$, $P < 0.05$; KW, $\chi^2 = 15.08$, df = 5, N = 3 (1; refer to Table 2.4, Chapter II General Methods for group composition ranks), 4 (2), 2 (3), 2 (4), 2 (5), 12 (6), $P < 0.05$; post-hoc comparison showed no significant comparison for any pair).

Time of feeding was negatively correlated with, presenting (with lipsmacking) and moving away (corrected for enclosure size, presenting with lipsmacking (ignored by male), $\rho = -0.4133$, $P < 0.05$; corrected for enclosure type, moving away, $\rho = -0.5368$, $P < 0.01$). Individuals that were fed once a day displayed all three behaviours much more frequently than did animals fed twice or thrice a day (KW, presenting with lipsmacking (ignored by male), $\chi^2 = 12.89$, df = 5, N = 1 (1; refer to Table 2.4, Chapter II General Methods for feeding time ranks), 5 (2), 3 (3), 7 (4), 8 (5), $P < 0.05$; moving away, $\chi^2 = 11.88$, $P < 0.05$; for post-hoc comparisons, refer to Table A4. in Appendix 4.2). Frequencies of total aggression negatively correlated with enclosure complexity, with individuals housed in barren enclosures exhibiting aggression more frequently than those housed in complex enclosures (corrected for rearing history, $\rho = -0.5541$, $P < 0.01$; post-hoc comparison showed no significant comparison for any pair).

Figure 4.1 Proportions of enclosure space used by captive lion-tailed macaques in Indian zoos

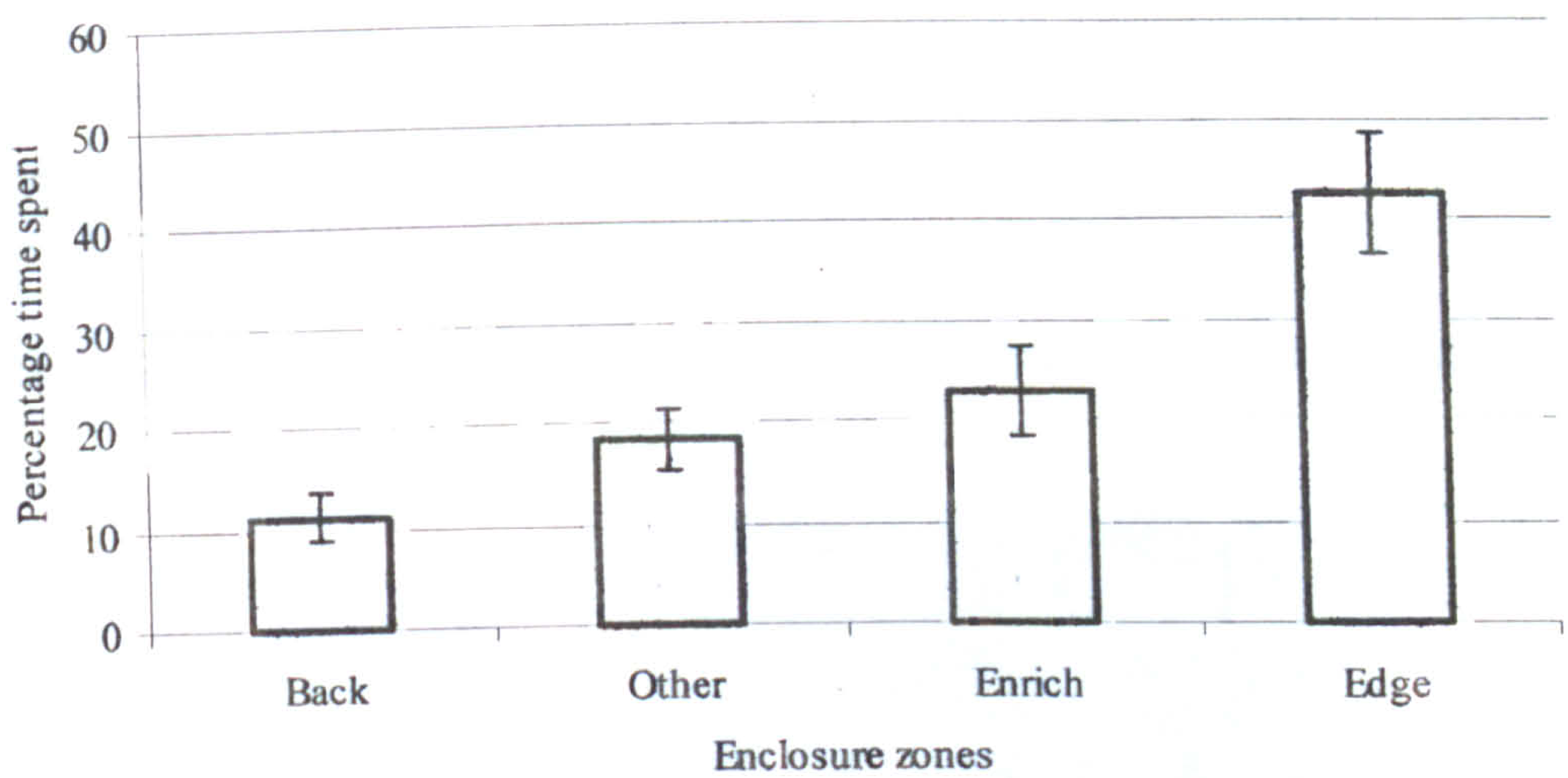


Plate 4.2 Lion-tailed macaques sitting at the edge of their enclosure closest to the visitor side at Thiruvananthapuram Zoo

Of all the zones, the percentage of time spent using the area of the enclosure closest to the visitor side (edge zone, 42.6 ± 5.9%) by captive lion-tailed macaques was the highest, followed by the enriched areas of the enclosure (enrich zone, 22.9 ± 4.5%), rest of the enclosure (other zone, 18.3 ± 3.0%) and the area further most from the visitor side (back zone, 11.2 ± 2.5%; Figure 4.1; Friedman's Test, $\chi^2 = 30.2$, df = 3, P < 0.001, N = 26 for post-hoc -wise comparisons, refer to Table A5. in Appendix 4.2).

Plate 4.3 Lion-tailed macaque female using the area of the cage closest to the visitor side

4.5.3.1. Use of the edge zone

The performance of abnormal behaviour was positively correlated, and food-related behaviour and social interactions negatively correlated with the use of the edge zone (Spearman's Correlation Test (SPT), abnormal behaviour, $\rho = 0.560$, $P < 0.005$;

food-related behaviour, $\rho = -0.547$, $P < 0.005$; social interactions, $\rho = -0.527$, $P < 0.05$). Lion-tailed macaques used the edge zone more in smaller zoos than larger zoos (Plate 4.2 & 4.3; corrected for rearing history, $\rho = -0.5321$, $P < 0.01$; for other partial correlations refer to Table 4.7; U = 19.500, N = 11 (small zoos) and 15 (large zoos), $P < 0.001$). The percentage of time spent in the edge zone was also negatively correlated with enclosure complexity, with animals housed in barren enclosures using the edge zone more than those housed in complex exhibits (corrected for rearing history, $\rho = -0.6296$, $P < 0.005$; KW, $\chi^2 = 12.84$, df = 2, N = 9 (barren), 10 (barren-but-enriched), 7 (complex), $P < 0.005$; for post-hoc comparisons, refer to Table A6. in Appendix 4.2).

Table 4.7. Partial correlations of enclosure zone use to different individual characteristics and captivity factors

Correlation	Correlation coefficient	P value	Constant factor
Edge – zoo category	-0.5385	0.005	Housing
Edge – zoo category	-0.5321	0.006	Rearing history
Edge – zoo category	-0.4861	0.014	Sex
Edge – zoo category	-0.5200	0.008	Vertical access
Edge – zoo category	-0.5192	0.005	Enclosure substrate
Edge – zoo category	-0.4528	0.023	Enclosure complexity
Edge – enclosure complexity	-0.6296	0.001	Rearing history
Edge – enclosure complexity	-0.6153	0.001	Zoo category
Edge – enclosure complexity	-0.5837	0.002	Sex
Edge – enclosure complexity	-0.3960	0.05	Vertical access
Edge – enclosure complexity	-0.5596	0.004	Enclosure substrate
Edge – enclosure complexity	-0.6002	0.002	Enclosure type
Edge – enclosure complexity	-0.6179	0.001	Housing
Enrich – vertical access	0.6086	0.001	Rearing history
Enrich – vertical access	0.5875	0.002	Zoo category
Enrich – vertical access	0.5767	0.003	Sex
Enrich – vertical access	0.6492	0.000	Enclosure substrate
Enrich – vertical access	0.6589	0.000	Enclosure type
Enrich – vertical access	0.3941	0.05	Enclosure complexity
Enrich – vertical access	0.6027	0.001	Housing

4.5.3.2. Use of the enrich zone

The exhibition of autogrooming, social interactions and food-related behaviours were all positively correlated with the use of the enrich zone by the study individuals (SPT, autogrooming, $\rho = 0.555$, $P < 0.005$; food-related behaviour, $\rho = 0.433$, $P <$

0.05; social interactions, $\rho = 0.484$, $P < 0.01$). The utilisation of the enrich zone was also positively correlated with access to the vertical dimension. Animals housed in enclosures that had access to the vertical dimension thus used the enrich zone more than those housed in enclosures that had no access (corrected for rearing history, $\rho = 0.6086$, $P \leq 0.001$; $U = 4.00$, $N = 8$ (no vertical access) and 18 (vertical access), $P < 0.001$).

4.5.3.3. Use of the back and other zones

Food-related behaviours were positively correlated and active behaviours were negatively correlated with the use of the other zone (Food-related behaviour, $\rho = 0.508$, $P < 0.01$; active behaviour, $\rho = -0.475$, $P < 0.005$). Animals housed in enclosures that were 10 to 20m^2 in size used the back zone significantly greater percentages than did those housed in enclosures less than 10 m^2 in size (corrected for zoo code; $\rho = 0.4051$, $P < 0.05$; KW, $\chi^2 = 12.77$, $df = 3$, $N = 7$ (<100 m^2 in size), 9 (100-200m^2), 4 (200-300m^2), 5 (> 300m^2), $P < 0.01$; for post-hoc -wise comparisons, refer to Table A6. in Appendix 4.2).

4.6. DISCUSSION

4.6.1. Ethogram of captive and free-ranging lion-tailed macaques

Several studies have documented the behaviour of lion-tailed macaques in captivity (Skinner & Lockard 1979; Johnson 1985) and in the wild (Kumar 1987; Raghavan 2001).

A considerable degree of variation was found when the ethograms of the captive lion-tailed macaques housed in Indian zoos and those in previous studies (eg Skinner & Lockard 1979; Johnson 1985) were compared. The most distinct of these was with regard to the abnormal behaviours recorded in this study on the captive Indian population. Skinner and Lockard (1975) and Johnson (1985) do not refer to any forms of abnormal behaviour when they discuss the behaviours displayed by the captive lion-tailed macaques in their study. This suggests that either abnormal behaviour was not recorded by the observer, or perhaps the study animals did not display these behaviours. The primary objective in both studies (eg Skinner & Lockard 1975; Johnson 1985) was to record social interactions between individuals within the group and this suggests that the emphasis might have been on social and reproductive behaviour rather than welfare. Also, since the lion-tailed macaques observed in these studies were housed in groups in comparison to the lion-tailed macaques in Indian zoos that were mostly housed singly or in pairs, there could be a high probability that the study animals in the previous studies did not display abnormal behaviours. Most of the social interactions documented by Skinner and Lockard (1975) and Johnson (1985) were also observed in this study on the captive Indian population. However, "head-toss" (Skinner & Lockard 1975), was not observed. According to Skinner and Lockard (1975), the study animal tossed its head usually at the end of a threat display. Finally, play and infant-related behaviours were hardly observed in the study on captive lion-tailed macaques in Indian zoos in comparison to the earlier studies. This was due to low number of infants, juveniles, and sub-adults in Indian captive population during the study period (refer to Table 2.1 in Chapter II *General Methods* for number of infants, juveniles and sub-adults). Also, since this study was on the welfare of captive lion-tailed macaques, the emphasis was on the abnormal behaviours exhibited, which resulted in only the most prominent of the normal behaviours being documented and recorded.

A similar difference was found when the ethograms for the Indian captive lion-tailed macaque population and for the free-ranging lion-tailed macaques were compared. Lion-tailed macaques housed in Indian zoos were found to exhibit several behaviours (eg autogrooming, masturbating and scratching) to notably higher or lower proportions to those exhibited by free-ranging individuals (refer to Raghavan 2001). Some of the individuals in this study were found to direct social interactions such as affiliative bared-teeth face, warning growl and aggression to themselves. In the study conducted on wild lion-tailed macaques, Raghavan (2001) observed her study animals directing these behaviours only to other animals.

The behavioural repertoire of captive lion-tailed macaques in this study was found to vary considerably from those of free-ranging individuals and also from other studies conducted on captive animals. As discussed earlier, the behaviours exhibited by captive animals such as primates in captivity depend, to a large degree, on the artificial environments in which they are housed (Appleby & Waran 2000). Captive primates need be provided with the appropriate environmental stimuli in order promote the exhibition of species-specific behaviour. Certain factors such as group composition, enclosure design, rearing history, visitor influence and provision of environmental enrichment are known to influence the behaviour and welfare of captive primates (refer to Section 1.4 *Primates in Captivity* in Chapter I *Literature Review*). The influence of these factors on the behaviour and welfare of lion-tailed macaques housed in Indian zoos have been discussed in detail in the following sections of this chapter and in Chapters V (influence of physical and social enrichment), VI (influence of visitor presence) and VIII (factors influencing primate welfare).

4.6.2. Factors influencing captive primate behaviour and welfare

Wild animals maintained in captivity in the care of humans are often kept under conditions that generally prevent them from exhibiting their natural, species-specific behaviours. In these cases, the occurrence and levels of abnormal behaviours in an individual's behavioural repertoire is one of the methods used to assess an animal's ability to cope with its environment (Petherick & Rushen 2000).

4.6.2.1. Influence of rearing history

In this study, captive lion-tailed macaques housed in Indian zoos were observed to exhibit 25 types of qualitative abnormal behaviours and nine types of quantitative behavioural pathologies. Interestingly, only confiscated and zoo-born individuals exhibited abnormal behaviours, while wild-caught or captive-reared individuals never exhibited them. Of these behaviours, self-mutilatory behaviours such as self-biting and biting hand, self-stimulatory behaviours such as hold penis and lick nipple and regurgitation/ reingestion were only exhibited by confiscated animals and almost never by zoo-born, captive-reared and wild-caught animals; confiscated individuals are those that have a history of being isolate-reared. Many research studies conducted on the development of behavioural pathologies have shown that self-mutilatory (for example self-biting) and self-stimulatory behaviours (for example holding penis and licking nipple) could have developed at an early stage in life (Anderson & Chamove 1980, 1985; Erwin & Deni 1979; Chamove & Anderson 1981; Chamove *et al* 1984; Mootnick & Baker 1994; Mallapur & Choudhury 2003; Mallapur in press). It has been suggested that self-mutilatory and self-stimulatory behavioural pathologies, especially self-aggression, are forms of redirected social behaviours (in this case, self-aggression would be redirected social aggression) exhibited by individuals in the absence of social targets (Erwin & Deni 1979; Anderson & Chamove 1980; Chamove *et al* 1984). These behaviours probably increase sensory inputs in poor environments (Erwin & Deni 1979; Chamove *et al* 1984; Anderson & Chamove 1985; Mootnick & Baker 1994). Several other forms of behavioural pathologies were exhibited most frequently by confiscated animals and almost never by zoo-born individuals. These behaviours such as floating-limb, self-biting, auto-erotic stimulation probably developed in captive individuals housed in environmentally or socially deprived conditions. Conversely, wild-caught and captive-reared individuals exhibited greater levels of certain normal behaviours such as climbing and stretching since these classes included individuals that were free-ranging probably during the crucial early years of development.

Some abnormal behaviour patterns could develop due to the unstimulating environments that the animals are housed in at that time. Due to the lack of appropriate environmental stimuli, natural behaviours are often temporarily suppressed due to behavioural deprivation and are replaced by abnormal behaviours when the animal is housed under inappropriate conditions (Mench & Mason 2000). In primates, these behaviours include begging, stereotypic pacing, hyper-aggression and self-directed social behaviours such as affiliative bared-teeth face, affiliative grunt, warning growl, bared-teeth display and eye-flash. This behavioural deprivation could also lead to certain other behavioural patterns being exhibited at abnormally high levels. This occurred in several self-directed behaviours (for example autogrooming, body-shaking, inspecting penis, masturbation, scratching body and yawning) and social behaviours (for example affiliative bared-teeth face, bared-teeth display and eye-flashing) in this study.

4.6.2.2. Influence of group size and composition

Behavioural deprivation could be influenced by several factors, such as group composition, enclosure design and feeding time. Housing primates singly or in group compositions that are inappropriate for the species invariably results in a reduction in natural behaviours (Erwin & Deni 1979; Anderson & Chamove 1980, 1985; Rendall & Taylor 1991). Lion-tailed macaques in the wild live in multi-female groups with infants and juveniles; such groups usually have 1-3 males (Kumar 1995; Raghavan 2001). Housing captive individuals in groupings such as this may reduce levels of stress that individuals would incur in inappropriate social groups. However, in this study group composition did not have a significant influence on behaviour.

4.6.2.3. Influence of enclosure design

Enclosure design also influences the behavioural repertoire of a captive animal. Individuals housed in naturalistic exhibits consisting of several trees, saplings, undergrowth, water bodies and a soft substrate foraged more than did animals housed in barren enclosures. These naturalistic enclosures not only provide adequate forage for a species such as the lion-tailed macaque, which spends 22 to 24% of its time foraging in the wild (Raghavan 2001), but also attract insects and other live food; this, in turn, provides the appropriate stimulus to motivate the captive macaques to forage and exhibit other exploratory behaviours.

In this study, captive macaques housed in barren cages with a concrete flooring rarely foraged due to the lack of an opportunity to do so. These individuals were also, in most cases, socially deprived. Barren cages also make it easier for visitors to come in physical contact with the captive animals, leading to high levels of aggressive behaviours directed towards humans and feral animals such as dogs and cats. Primates housed in unnaturally barren environments and in small exhibits are not stimulated to express their natural repertoire of behaviours (Reinhardt *et al* 1995, 1996; Reinhardt 1997). It has been observed that animals housed in sub-optimal environments develop a wide range of abnormal behavioural patterns (Clarke *et al* 1982; Goerke *et al* 1987; O'Neill *et al* 1991) and are also less active (Macedonia 1987) than those housed in naturalistic environments.

The behavioural repertoire of captive animals differs considerably from that of their free-ranging counterparts in its diversity and in the levels at which certain behaviours are exhibited. The main reason for such an obvious difference in their activity budgets is the absence of species-typical environmental stimuli in captivity. This study shows that enclosure design and rearing history are some of the environmental factors that have a profound influence on the behaviours exhibited by these individuals, including the development of severe behavioural abnormalities. Only individuals that were either housed in barren cages, in species-inappropriate groupings or had experienced social deprivation during early development exhibited some of these behavioural pathologies. Such individuals also displayed fewer natural behaviours, both qualitatively and quantitatively, such as coughing, stretching, foraging and grooming. These environmental factors thus clearly play an important role in the behavioural management and husbandry of lion-tailed macaques; it is imperative that they be considered while building new exhibits or while forming new captive groups for this species.

4.6.3. Use of enclosure space by captive lion-tailed macaques

Animals are motivated to perform a variety of behavioural patterns primarily due to the presence of appropriate environmental stimuli. Certain environmental factors, specific to a given area, stimulate the animal to exhibit certain behaviours or specific behavioural sequences. Simil~~arly, in captive environments, certain areas within~~ the enclosure probably stimulate the animal to exhibit particular behavioural patterns. In this study, individuals were observed to use certain enclosure zones to exhibit specific behavioural patterns; abnormal behaviours, for example, were exhibited predominantly in the edge zone. There could be several probable explanations for this. The edge is the area of the enclosure closest to the visitors and animals can maximise visitor interaction, which includes being fed by the visitors, by spending more time in this zone (Mallapur *pers. obs.*). Also, when an animal tries to escape from its enclosure, it tries to do so from the edge. When the animal is unable to escape from one location, it tries from other locations, walking or running up and down along the edge of the enclosure in order to get out (Mason 1991).

It has been suggested that the incidence of stereotyped behaviours in several species of primates is linked to an environment deficit (Redshaw & Mallinson 1991). The need to maximise movement and natural behaviours has been recognised by modern captive facilities such as Jersey Zoo, which has resulted in little or no stereotyped movements being exhibited by the animals housed in their enriched primate exhibits. Lack of such enrichment could give rise to abnormal behaviours such as stereotypic pacing. The macaques in this study exhibited higher levels of social interactions and food-related behaviours in the enrich zone while lower levels of active behaviours were displayed in the back zone. The enrich zone usually consisted of features such as sleeping platforms, trees, bushes or even a water body. The safe upper reaches of a tree or even a sleeping platform could motivate individuals to forage and interact with one another. Similarly, in free-ranging lion-tailed macaques, intermediate trees and branches were primarily used for foraging and feeding while the canopy was preferred while surveying surrounding areas (Raghavan 2001). The back zone was the area of the enclosures in front of the gate connecting to the off-exhibit enclosures, where the animals were usually fed. In this area, captive lion-tailed macaques sat and waited in anticipation of being fed, leading to low levels of behavioural activity.

The edge was the most frequently used zone, with animals spending as high as 43% of the time in this zone. Interestingly, individuals housed in smaller, barren cages tended to use the edge more than those housed in large naturalistic enclosures. In small barren cages, the absence of appropriate environmental stimuli, which provides the necessary sensory input to develop species-specific behaviour patterns, probably lead captive individuals housed in these enclosures to depend on an external stimuli such as visitor interaction. Naturalistic enclosures, however, provide animals with an ideal environment to exhibit species-typical behaviour. Animals in these enclosures spent more time in the enriched portions of the enclosure, which typically included features such as trees, bushes and water bodies (trees were not planted along the edges of the enclosures since animals can escape through the overhanging branches). Similar observations were made in a study on captive carnivores, which showed that large cats spent two-thirds of their time along the periphery of their enclosures (Baldwin 1985).

4.7. CONCLUSIONS

4.7.1 Ethogram

During the behavioural study on captive lion-tailed macaques in Indian zoos, six behavioural states and 34 behavioural events that were abnormal were documented. Animals that were confiscated from private owners, which suggested that they had had considerable contact with humans, exhibited most of these abnormal behaviours.

4.7.2. Factors influencing behaviour

The behaviour and welfare of captive lion-tailed macaques in India is profoundly influenced by enclosure design, feeding regime and rearing history. Behavioural deprivation caused by the absence of appropriate environmental stimuli such as naturalistic enclosures and species-specific groupings influences the behavioural repertoire and the exhibition of abnormal behaviours by captive macaques in most Indian zoos. Social deprivation during early rearing experience could cause the development of self-mutilatory and self-stimulatory behavioural pathologies such as floating limb, self-biting, holding penis and licking nipple. Therefore, Indian zoos intending to house lion-tailed macaques as part of long-term breeding programmes need to strongly consider providing adequate housing and appropriate animal groupings during all stages of life so that the animals' welfare is not compromised in any way.

4.7.3. Space use

In this study, it is evident that captive lion-tailed macaques used the edge zone when their captive environments were deficient in appropriate environmental stimuli. The fact that the captive lion-tailed macaque population in this study largely used the space closest to the visitor area (edge zone) to display their behaviours, suggests that primate exhibit design in Indian zoos perhaps needs to be assessed and upgraded. The need for naturalistic exhibit design has been recognised by several modern zoos leading to the construction of larger more complex enclosures for several taxa including nonhuman primates such as orang-utans, gorillas and chimpanzees. The inclusion of natural features such as trees, bushes, sleeping platforms or water bodies provide access to the vertical dimension at varied and appropriate levels allowing movement and increasing locomotor activity in arboreal primates without the need to necessarily use the ground.

CHAPTER IV *Environmental Enrichment*

CONTENTS

Improving the Welfare of Captive Lion-Tailed Macaques (*Macaca silenus*) through the Use of Structural and Social Enrichment

5.1. ABSTRACT

Two enrichment techniques were devised with the aim of reducing stress and improving welfare for zoo-housed lion-tailed macaques in an Indian zoo. Two behavioural studies were conducted on two separate populations of six singly-housed captive macaques in Thiruvananthapuram Zoo in Thiruvananthapuram, southern India. In Study A, a log, cotton ropes and a feeding basket were added to the enclosures in different combinations to provide structural and feeding enrichment and subsequently removed, while in Study B, singly-housed individuals were transferred to a large open-moated enclosure in which they were group-housed. In Study A, the frequencies and percentages of time spent performing abnormal behaviours differed significantly across the experimental conditions, with the lowest percentages being exhibited when the singly-housed macaques had logs and ropes and were fed in elevated feeding baskets. Furthermore, the frequency of exploratory behaviours displayed by several of these individuals also increased, while self-biting decreased. Aggressive biting appeared to be redirected to the enrichment devices that were provided. In Study B, the six captive lion-tailed macaques exhibited significantly greater levels of abnormal behaviour when they were housed singly in barren cages than when they were housed together as a group in a complex enclosure. These individuals also displayed higher levels of active foraging when they were group-housed in the open-moated enclosure. These two enrichment techniques (social and physical) thus appeared to significantly improve the welfare of the study individuals by stimulating them to exhibit more natural behaviours together with the suppression of several abnormal behaviours.

Keywords: animal welfare, enrichment, abnormal behaviour, lion-tailed macaques, zoos, India

5.2. INTRODUCTION

The science of environmental enrichment was first outlined in Heini Hediger's work (1960) as a method to improve the standard of zoo environments housing wild animals. The art of enrichment is in providing the appropriate environmental stimuli necessary for improving the welfare of captive animals (Shepherdson 1998). In order to provide appropriate environments such as these, several zoos have incorporated administration of enrichment into their zoo management and husbandry protocols (refer to Section 3.5 *Results* of Chapter III *Questionnaire Survey*).

The administration of environmental enrichment is segregated into two distinct approaches, the naturalistic approach and the behavioural engineering (Young 2003). While the former focuses on creating a naturalistic environment in captivity by providing the appropriate species-specific stimuli, the latter focuses on the administration of certain devices, which the animals learn to operate in order to receive a reward (for example a apple from a food dispenser). However, while choosing a strategy to enrich primate enclosures, zoos have used either of the approaches (naturalistic approach, for example Zimmerman & Feistner 1996; behavioural engineering, for example Vick *et al* 2000).

Primate enclosures can also be improved by structurally enriching the enclosure space by providing enclosure furnishings (Kessel & Brent 1996; Hebert & Bard 2000) or by shifting the animals into a new enclosure (O'Neill *et al* 1991; Little & Sommer 2002). Young (2003) suggests a 'bottom up' approach in administration of enrichment starting with the enclosure substrate and then moving upwards. In the case of arboreal primates, the lowest branches form the enclosure substrate (Young 2003; for example Hebert & Bard 2000). The addition of certain enclosure furnishings can be used to stimulate the captive animals to exhibit certain species-specific behaviours (Young 2003; for example Ludes & Anderson 1996; Ludes-Fraulab & Anderson 1999).

Increasing the time spent by captive primates in foraging and feeding is another type of enrichment (Erwin 1979). Free-ranging primates spend a considerable proportion of their daily activity budget in feeding and foraging (Gupta 2001). While choosing a feeding enrichment programme, care should be taken to identify those that are appropriate to the species in question (Young 2003). For example, insect/ mealworm dispensers can be used in the case of insectivorous primates while hanging feeding baskets filled with fruits can be used for omnivores.

Most primate species, including the lion-tailed macaque live in large social group in the wild (Gupta 2001). It has been suggested that the best method to improve the welfare of social species in captivity is to house them in species-appropriate social groups (Young 2003). Housing these species asocially could hamper the normal development of social behaviour and also influence them to react incongruously to the social signals of their species (Young 2003).

In behavioural study (Chapter IV) it was found that confiscated lion-tailed macaques exhibited a greater diversity and levels of abnormal behaviour. Levels of abnormal behaviour exhibited were also found to be influenced by enclosure complexity. The structural enrichment study in this chapter was thus designed to examine whether provision of elevated logs, ropes and feeding baskets would stimulate the confiscated lion-tailed macaques to exhibit natural behaviours such as climbing, swinging and foraging. The social enrichment study in this chapter was in turn designed to examine whether the provision of conspecifics stimulated the singly-housed confiscated lion-tailed macaques to display higher levels of natural social behaviours.

5.3. AIM

The aim of this chapter was to devise cost-effective enrichment that would provide the appropriate environmental stimuli required to motivate captive lion-tailed macaques to exhibit a more natural behavioural repertoire. A structural and social enrichment study was conducted on subsets of the Indian captive population of lion-tailed macaques.

5.4. METHODS

5.4.1. General methods

Thiruvananthapuram Zoo in the city of Thiruvananthapuram, the state capital of Kerala in southern India, maintains 15 captive lion-tailed macaques, of which nine are males and six females. Of the 15 animals, two males and four females were singly-housed in the primate house which was connected to the main out-door lion-tailed macaque exhibit. All the six individuals were also previously housed in pairs or groups and hence were ideal for the social enrichment study. Of the 15 animals, two females and one male were not observed since they were undergoing treatment at the zoo hospital. The remaining six males were surplus animals (surplus from an exhibit and breeding point of view). These individuals were permanently housed in isolation (no contact with conspecifics), in small cages were chosen for the structural enrichment study. The cages that these six macaques were housed in did not have access to the main out-door lion-tailed macaque exhibit.

Study A was therefore conducted on six singly-housed male lion-tailed macaques housed at Thiruvananthapuram Zoo. All six individuals were confiscated from touring in small, unrecognised zoos and circuses and were subsequently housed in small cages of similar design. Study B was conducted on another set of six captive lion-tailed macaques – two males and four females – also housed at Thiruvananthapuram Zoo. The behaviour of these six individuals was first recorded when they were housed singly in small barren cages and then again once they were grouped together in a new enclosure. The lion-tailed macaques were fed at 1230 and 1600 h and the keepers cleaned the enclosures between 0900 and 1000 h. The animals were fed on a mixture of vegetables, fruits, cereals, nuts, bread and boiled eggs (for quantities, refer to Table 2.3 in Chapter II *General Methods*).

Plate 5.1 Feeding basket attached to cotton ropes in a lion-tailed macaque enclosure at Thiruvananthapuram Zoo

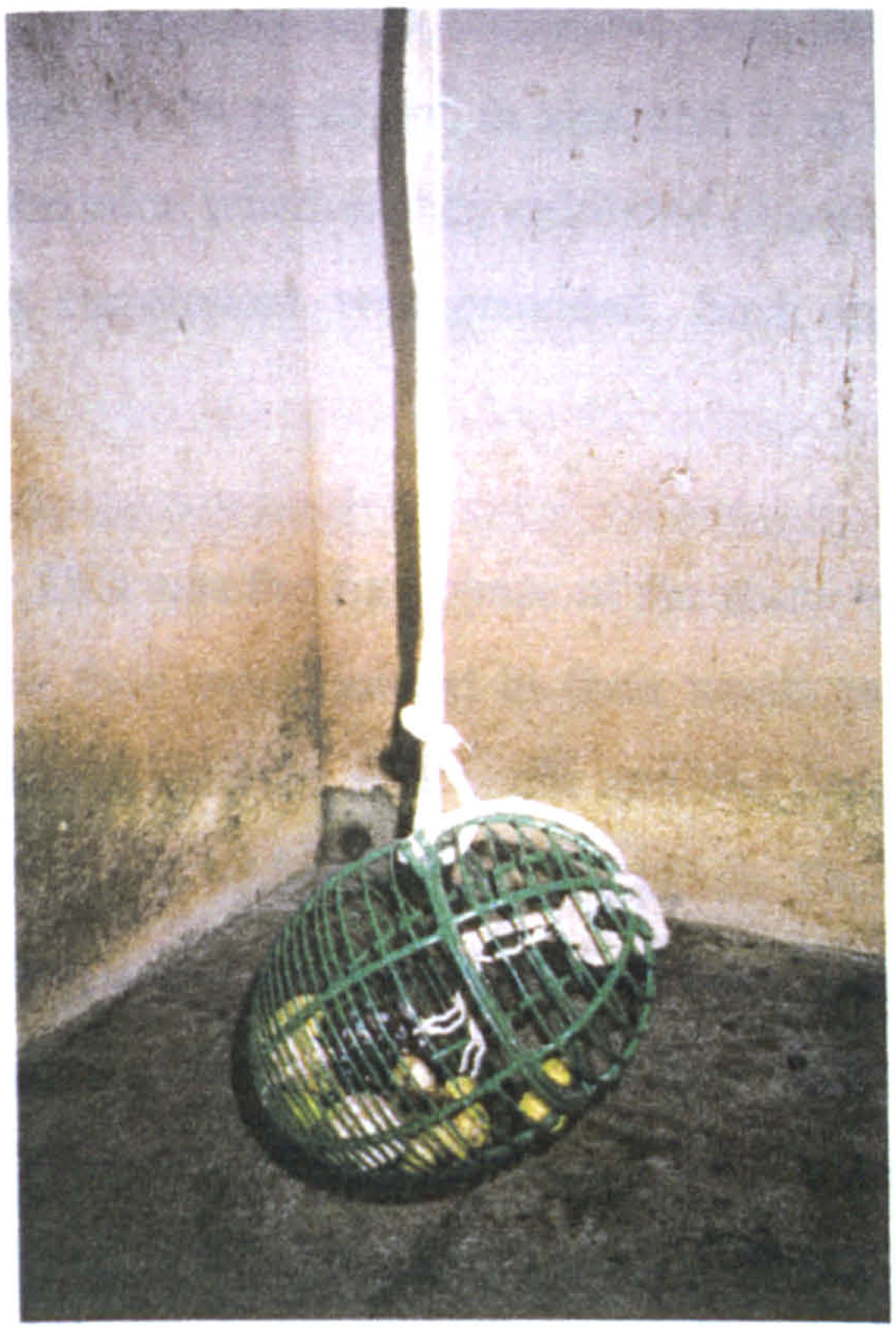


Plate 5.2 A fruit and vegetable diet for the lion-tailed macaques' 1230 h feed

5.4.2. Study design

5.4.2.1. Study A: Since all six lion-tailed macaques were housed singly in small, barren cages of approximately 20 to 25 m^2 in size and 3 m height, an enrichment study was designed to determine whether they exhibited changes in their behavioural repertoire when suitable enrichment was provided. Each individual was studied during five phases;

Phase 1. 'The control': This was the first phase of the study when the animals were observed when they were housed in their small cages. The cage at this stage consisted only of the four walls and the concrete floor. Enclosure furnishings were not added during this phase. During feeding time, the food was scattered on the floor. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent observing each individual was (± SE) 4.67 ± 0.69 h (N = 6) for a total period of 28.00 hours.

Phase 2. 'Cage + log and ropes': After observing the study animals in the control phase, the second phase involved adding enclosure furnishings to the barren cages. These furnishings included a horizontal log, which was placed at 3 m height from the ground to which two cotton ropes were attached 1 m apart from each other. The cotton ropes were allowed to hang up to 1 m off the ground. Food was scattered on the cage floor during this phase of the study. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent observing each individual was 3.08 ± 0.17 h (N = 6) for a total period of 17.50 hours.

Phase 3. 'Cage + logs and ropes + feeding basket': In this phase, a feeding basket was hung 1 m off the ground attached to the end of one of the ropes. The feeding basket was made of iron bands with gaps of four to six cm in between the bands so that the individuals could see and even touch food items in the basket. The food items could only be removed from the top of the feeding basket. To achieve this, the macaques had to stand on their legs to retrieve the food successfully. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent observing each individual was 2.83 ± 0.18 h (N = 6) for a total period of 18.50 hours.

Phase 4. 'Cage + logs and ropes (feeding basket removed)': In this phase, the feeding basket was removed but the ropes and log were left in place. Food was scattered on the cage floor during this phase of the study. This phase was thus similar to the second phase of the study. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent observing each individual was 3.08 ± 0.08 h (N = 6) for a total period of 17.00 hours.

Phase 5. 'Cage (logs and ropes removed)': In the fifth phase, the ropes and log were removed and the cage was restored to the condition that it was in during the first phase of the study. Food was scattered on the cage floor during this phase of the study. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent observing each individual was 2.92 ± 0.11 h (N = 6) for a total period of 18.50 hours.

An 'A-B-C-B-A' study design was used, which involved the addition of certain enclosure furnishings and then their removal in order to restore the captive environment to its original state. This design proves to be more rigorous than 'A-B-C' since, behaviours that increase from phases A to C of the study should decrease from phases C to A and vice versa in order to associate the enrichment administered with the behaviour differences observed.

5.4.2.2. Study B: At the start of the study, all six lion-tailed macaques were housed singly in small, barren cages of approximately 20 to 25 m^2 in size. The outdoor, open-moated exhibit was > 300 m^2 in size. This study investigated the changes in behaviour that occurred when the singly-housed macaques were moved into a larger enclosure and grouped together.

Phase 1. 'Singly-housed in barren cages': The behaviour of the six individuals was recorded when they were housed in cages. Individuals were housed in neighbouring cages and hence, could interact with one another. Each individual was studied for a period of three days, with the second and third days being pseudo-replicates of the first. The mean period of time spent was 4.35 ± 0.51 h (N = 6) for a total period of 22.75 hours.

Phase 2. 'Group-housed in an open-moated enclosure': Fifteen days after the end of the first phase, all six individuals were released into the same complex open-moated enclosure. Of the six animals (two males and four females), one male and two females had been housed together before. The remaining animals were new to the group. The open-moated enclosure was approximately > 300 m^2 in size in total and contained several trees, bushes and a water body. Each individual was studied for a period of five days, with the second, third, fourth and fifth days being pseudo-replicates of the first. The mean period of time spent was 4.54 ± 1.77 h (N = 6) for a total period of 27.25 hours.

While the enrichment study (Study A) focused on the changes in the physical aspects of enclosure space, the social study (Study B) focused on the changes in the social aspects of the captive environment.

5.4.3. Data sampling

5.4.3.1. Behavioural sampling

In Study A, each lion-tailed macaque was observed for a continuous period of three hours during the day; this session was located between feeding time, at approximately 1130 h, until the time the zoo closed, at approximately 1730 h. The same sampling method was used to observe all the six macaques. The behaviour of each individual was recorded during each of the five phases of the behavioural study (refer to Table 5.1 & for definitions of behaviours refer to Appendix 4.1).

In Study B, lion-tailed macaques were observed for a continuous period of five hours during the day between the time the zoo opened in the morning, at approximately 0830 h, to the time it closed, at approximately 1730 h. During the second phase of Study B when the animals were grouped together, the six individuals were observed in pre-determined order (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*) for one hour per animal per day over a period of five days.

Both studies were conducted between February and October 2003. During the study, a combination of focal animal sampling and instantaneous scanning was used to quantify the behaviour displayed by the captive macaques (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). The behaviour of each individual was only recorded when visitors were present and not on zoo holidays. Each behavioural sampling session was initiated with an instantaneous scan, and was followed by a focal animal sample of one of the individuals in the group for a duration of 15 min (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*).

5.4.3.2. Space use

The use of enclosure space by captive lion-tailed macaques was recorded during the instantaneous scans conducted to record the behavioural states (refer to Section 2.3 *Space Use* in Chapter II *General Methods*).

5.4.4. Data analyses

Behaviour and space use data for each individuals were pooled at the end of the observation period to obtain averages (refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). Refer to Section 2.4 *Data Analyses* in Chapter II *General Methods* for statistical analyses used.

Table 5.1. Behaviours recorded during the enrichment study that included behavioural states (A) and events (B). The third section consists of behaviours exhibited

A. Behavioural states recorded

Behavioural categories	Definition	Behaviours included
Rest-related behaviours	Behaviours with relaxed postures on any substratum	Sleep, sit, lie-down
Active behaviours	Continuous movement in a particular direction on any substratum	Run, climb, stand, walk
Food-related behaviours	Behaviours related to searching of food and feeding	Feeding, active foraging, passive foraging
Abnormal behaviours'	Undesirable behaviours exhibited in captivity only	Self-bite, floating limb and stereotypic pacing

B. Behavioural events recorded

Behavioural categories	Definition	Behaviours included
Affiliative behaviours	Friendly gestures between two or more individuals	Affiliative grunt and affiliative bared-teeth face
Aggressive behaviours	Agonistic acts between two or more individuals	Warning growl, bite, bared-teeth face and eye-flash
Reproductive behaviours	Sexual interactions between sexually mature males and females during oestrus	Mating, presenting and anal inspection
Abnormal behaviours	Undesirable behaviours exhibited in captivity only	Self-bite, floating limb, stereotypic pacing and bouncing

C. Enrichment-stimulated behaviours recorded

Behavioural categories	Definition	Behaviours included
Rope-chewing / log- gnawing	Chewing rope or gnawing logs added to enclosure	Rope-chewing, log-gnawing
Attempting to swing	Attempting to swing on ropes and feeding basket provided	Attempted swing, swing
Exploratory behaviours	Foraging and searching in feeding basket for particular food items	Searching, foraging

5.5. RESULTS

5.5.1. Study A

5.5.1.1. Relationship between behaviours and the different phases of the study

In Phase 1, resting behaviour was exhibited the most, followed by food-related behaviours, active behaviours and abnormal behaviours (Tables 5.1, 5.2 & Figure 5.1;

Friedman's test, $\chi^2 = 9.4$, df = 3, $P < 0.05$, $N = 6$; for post-hoc analysis refer to Table A1. in Appendix 5.1). In Phases 2, 3 and 4, a significant difference was found in the time spent performing various behaviours. The greatest percentage of time was spent in resting behaviours, followed by active behaviours, food-related behaviours and finally, abnormal behaviours (Tables 5.1, 5.2 & Figure 5.1; Phase 2, $\chi^2 = 13.2$, df = 3, $P < 0.005$; Phase 3, $\chi^2 = 9.6$, $P < 0.05$; Phase 4, $\chi^2 = 12.6$, $P < 0.01$; for post-hoc analysis refer to Table A1. in Appendix 5.1). There was no significant difference in percentages of the behaviours exhibited in phase 5.

Figure 5.1 Differences in the percentage time spent exhibitng various behaviours across the five phases of Study A

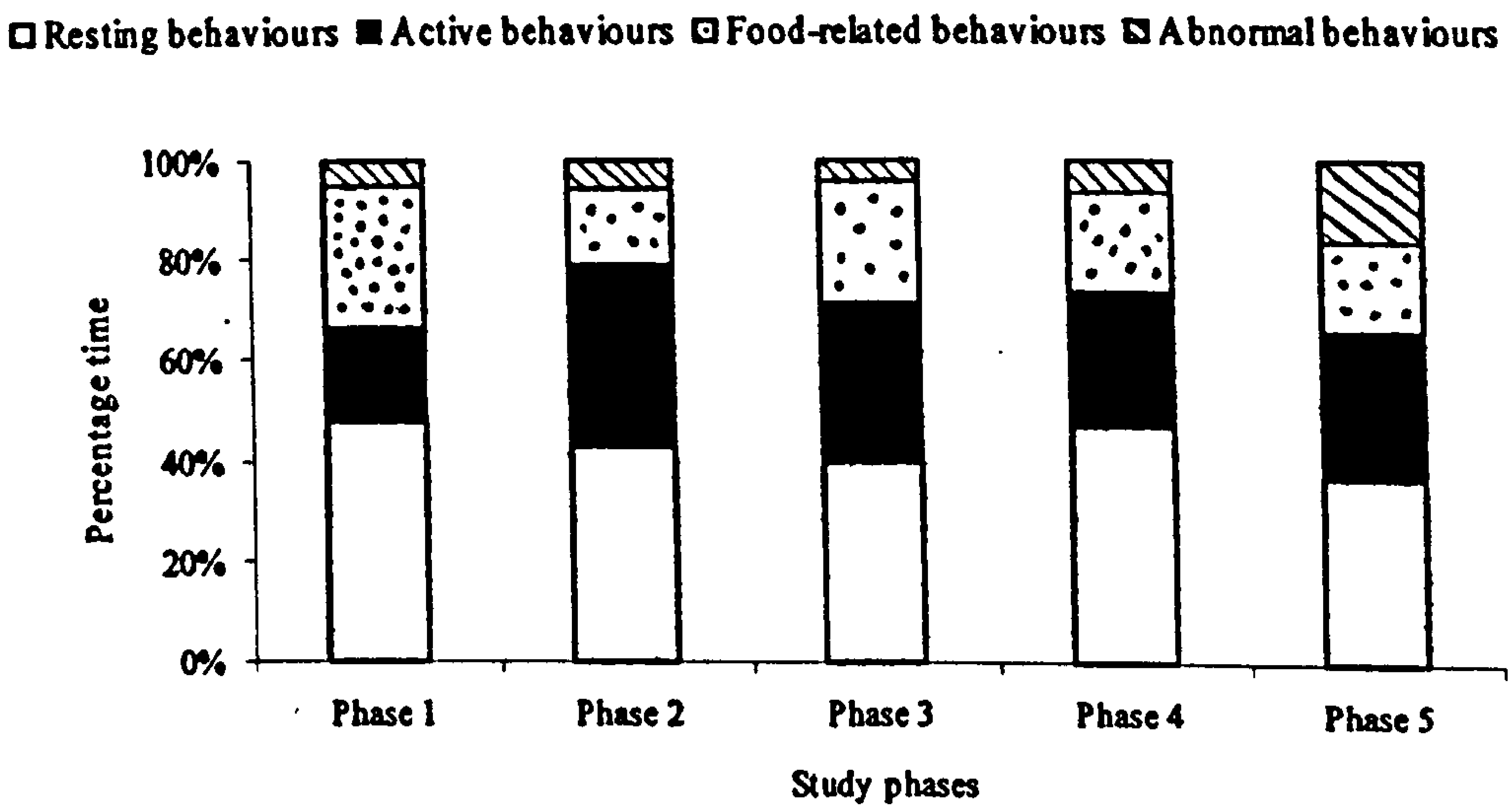


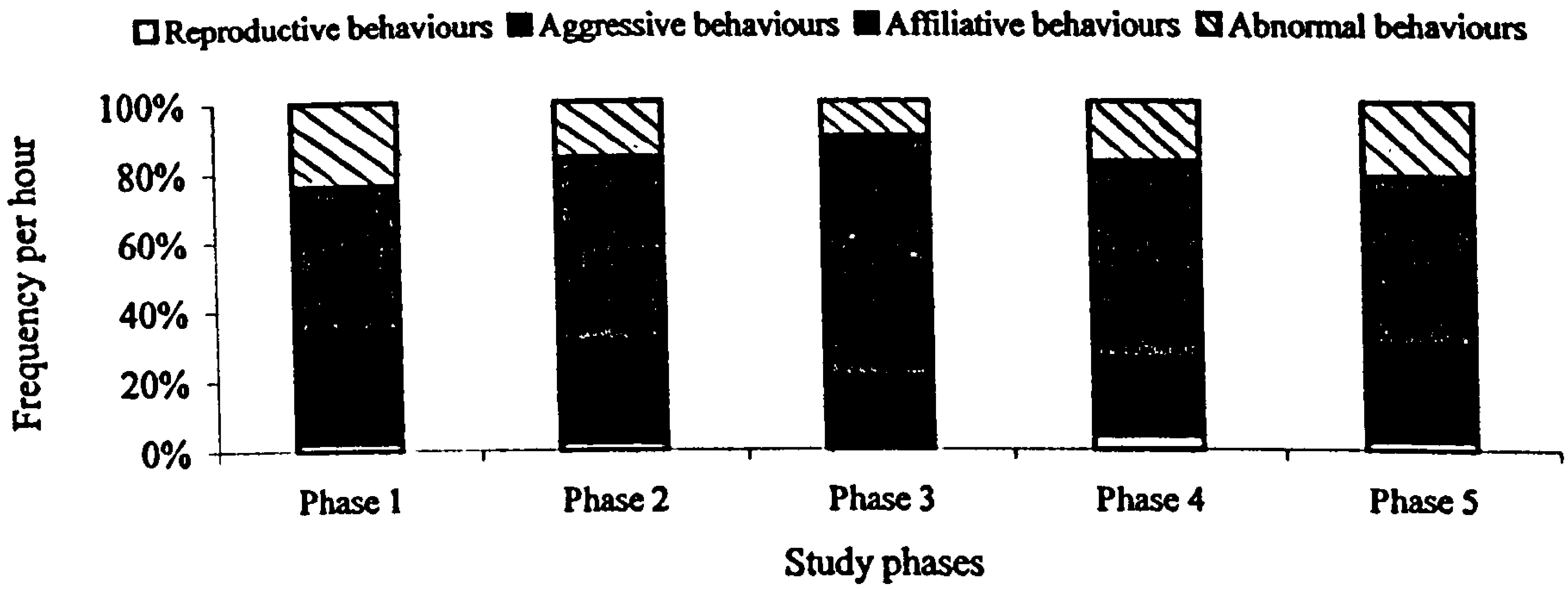
Table 5.2. Percentage distribution of different behaviours (mean ± standard error) exhibited during the five phases of Study A conducted on six singly-housed males at Thiruvananthapuram Zoo

Behaviours	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Resting	47.4 ± 7.3	42.5 ± 3.3	39.5 ± 5.6	47.1 ± 5.4	37.1 ± 7.3
Active	19.2 ± 4.8	36.4 ± 4.6	31.8 ± 3.9	26.6 ± 6.2	28.7 ± 7.4
Food-related	28.2 ± 7.9	15.4 ± 3.5	24.8 ± 9.0	20.3 ± 2.5	18.1 ± 3.6
Abnormal	5.1 ± 5.1	5.7 ± 3.9	3.8 ± 2.6	6.0 ± 4.0	16.1 ± 6.6

Table 5.3. Frequencies of different behaviours (mean ± standard error) exhibited during the five phases of Study A conducted on six singly-housed males at Thiruvananthapuram Zoo

Behaviours	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Reproductive	0.7± 0.7	0.9 ± 0.6	0.5 ± 0.5	1.4 ± 1.3	1.1 ± 1.2
Aggressive	9.9 ± 12.6	12.9 ± 8.0	8.5 ± 12.4	8.7 ± 15.8	13.2 ± 7.3
Affiliative	13.02 ± 9.0	23.7 ± 16.7	29.8 ± 35.4	21.8 ± 19.4	23.2 ± 18.5
Abnormal	7.3 ± 11.09	7.2 ± 9.6	4.3 ± 5.5	6.6 ± 9.05	10.1 ± 6.3

Figure 5.2 Differences in the frequencies per hour of various behaviours exhibited across the five phases of Study A



In all phases of the study, the frequency of affiliative behaviours was the highest, followed by aggressive behaviours, abnormal behaviours and reproductive behaviours (Table 5.3 & Figure 5.2, Phase 1, $\chi^2 = 8.4$, df = 3, $P < 0.05$; Phase 2, $\chi^2 = 13.6$, df = 3, $P < 0.005$; Phase 3, $\chi^2 = 15.3$, $P < 0.005$; Phase 4, $\chi^2 = 9.8$, $P < 0.05$; Phase 5, $\chi^2 = 10.1$, $P < 0.05$; for post-hoc analysis refer to Table A2. in Appendix 5.1).

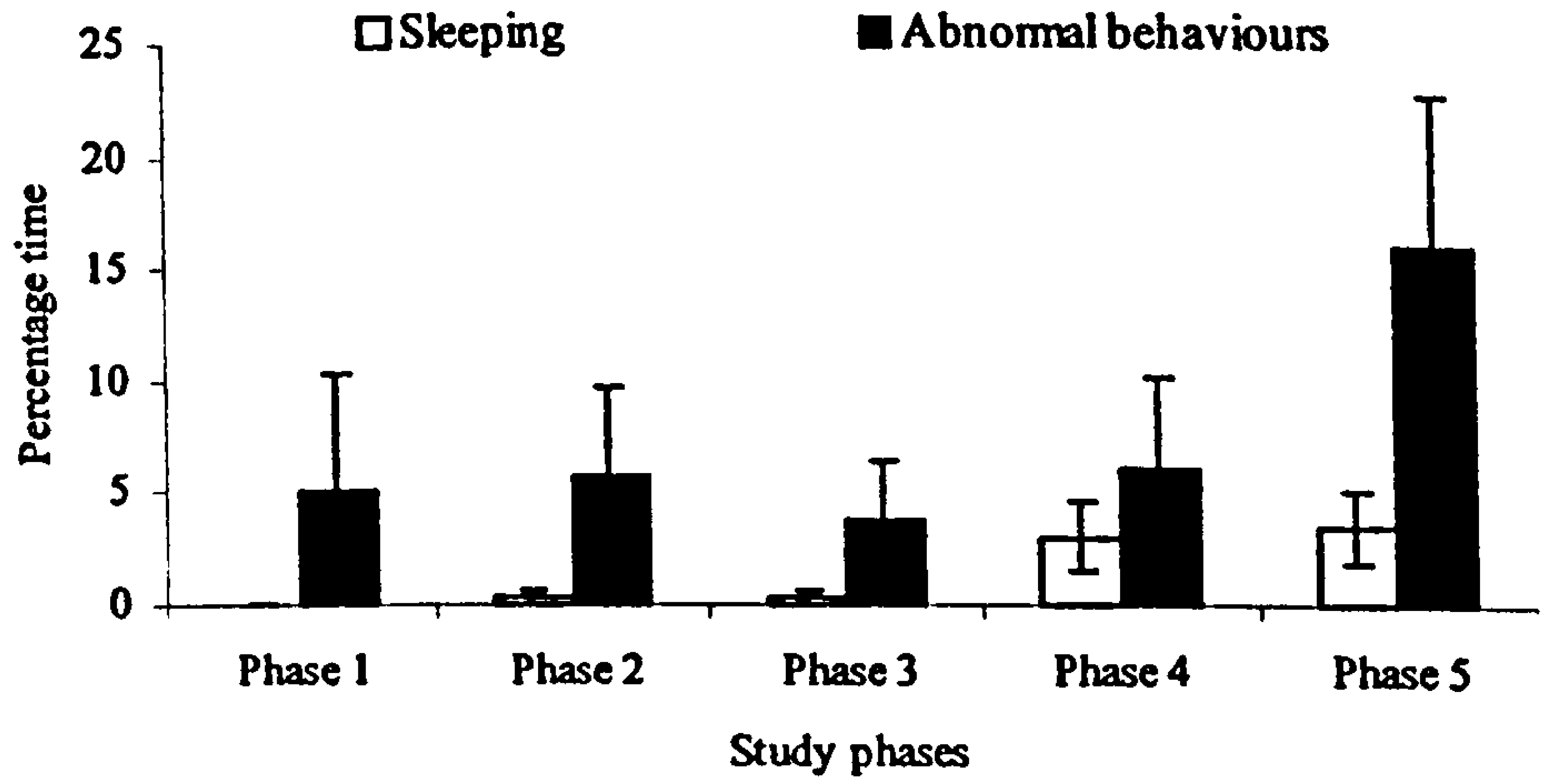
Table 5.4. Differences in percentage sleep and abnormal behaviour exhibited across the five phases of the Study A conducted on six singly-housed males at Thiruvananthapuram Zoo

Behaviour	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Sleeping	0.0 ± 0.0	0.3 ± 0.3	0.3 ± 0.3	3.4 ± 1.6	3.0 ± 1.5
Abnormal behaviours	5.1 ± 0.6	5.7 ± 4.0	3.8 ± 2.6	16.1 ± 2.2	6.0 ± 4.1

Table 5.5. Differences in frequencies per hour of attempted swing, exploratory behaviours and rope chewing exhibited across the five phases of the Study A conducted on six singly-housed males at Thiruvananthapuram Zoo

Behaviour	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Attempted swing	0.0 ± 0.0	2.0 ± 1.0	1.1 ± 0.5	1.8 ± 0.8	0.0 ± 0.0
Exploratory behaviour	0.0 ± 0.0	0.0 ± 0.0	6.7 ± 3.06	0.0 ± 0.0	0.0 ± 0.0
Rope chewing	0.0 ± 0.0	0.8 ± 0.5	1.3 ± 0.5	2.4 ± 0.8	0.0 ± 0.0

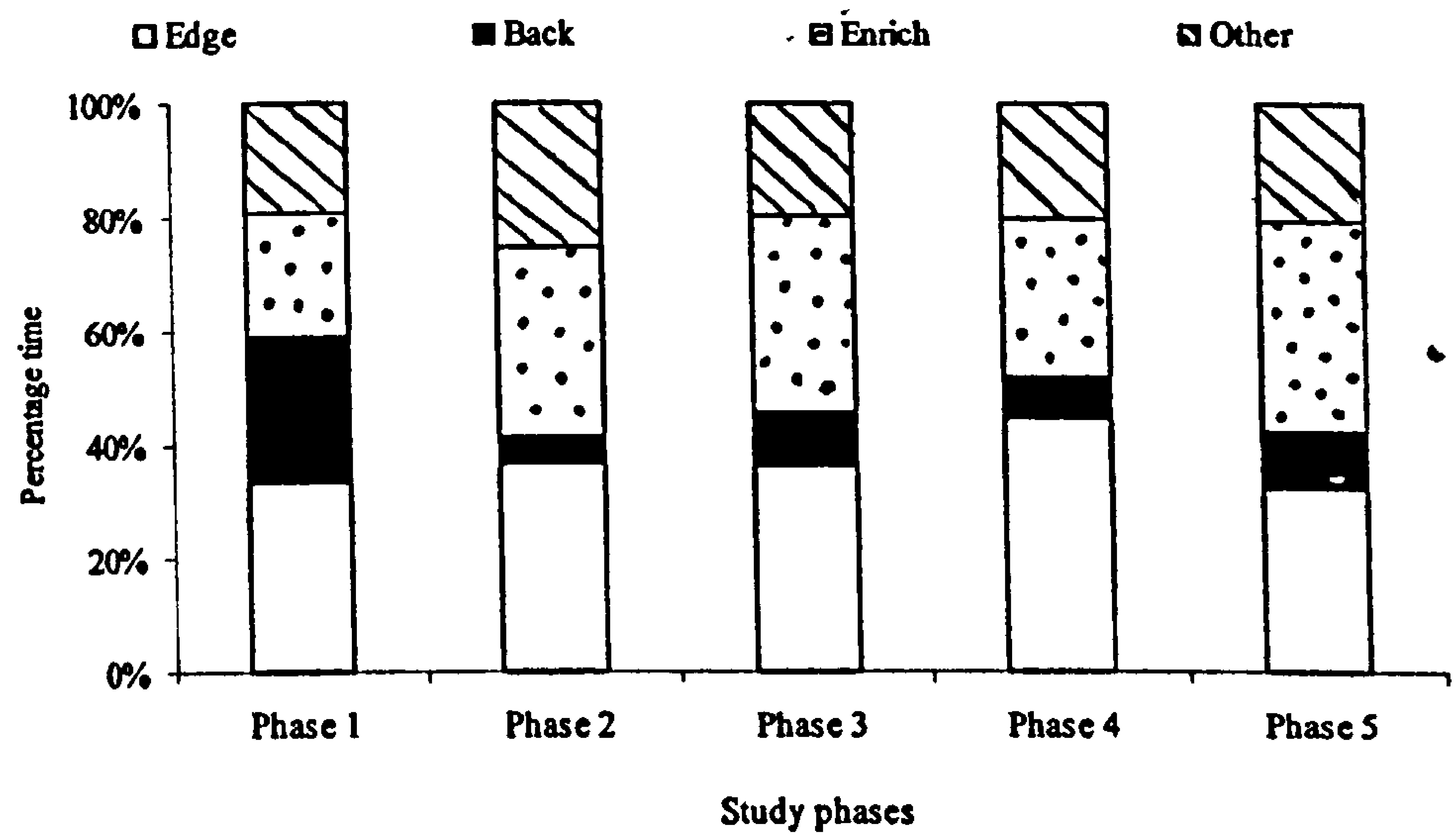
5.3 Differences in percentage sleep and abnormal behaviour exhibited across the five phases of Study A



5.5.1.2. The use and effect of enrichment on behaviour

The captive macaque males exhibited significant differences in the percentage of time that they spent sleeping during Phases 1 to 5 (Table 5.4 & Figure 5.3, $\chi^2 = 11.2$, df = 4, $P < 0.05$; for post-hoc analysis refer to Appendix Table A3. in Appendix 5.1). They slept significantly more during Phases 4 and 5 as compared to the other three phases. The percentage of total abnormal behaviour exhibited also differed across the five phases of the study (Table 5.4 & Figure 5.3, $\chi^2 = 14.1$, $P < 0.01$; for post-hoc analysis refer to Table A3. in Appendix 5.1). The highest percentage of time spent in the display of abnormal behaviour occurred during Phase 5, the least being during Phase 3. Similarly, the frequencies of self-biting and total abnormal behaviour were significantly higher during Phases 4 and 5, significantly lower in Phase 1, and least during Phases 2 and 3 (self-biting, $\chi^2 = 10.2$, $P < 0.05$; abnormal behaviour, $\chi^2 = 9.5$, $P < 0.05$; for post-hoc analysis refer to Table A3. in Appendix 5.1). The frequency of rope-chewing or log-gnawing and attempts made at swinging (refer to Table 5.1.) were significantly higher during Phases 3 and 4 when compared to Phases 1 and 2, while the frequency of exploratory behaviour was highest during Phase 3 when compared to Phases 1, 2, 4 and 5 (Table 5.5, rope-chewing or log- gnawing, $\chi^2 = 11.2$, $P < 0.05$; attempted swinging, $\chi^2 = 16.7$, $P < 0.005$; exploratory behaviour, $\chi^2 = 24.0$, $P < 0.001$; for post-hoc analysis refer to Table A3. in Appendix 5.1).

Figure 5.4 Differences in the percentage time spent in the enclosure zones by individuals observed during Study A



5.5.1.3. Use of enclosure space by captive lion-tailed macaques

The use of enclosure space varied during the different phases of Study A. In Phase 1, the area closest to the visitor side (edge zone) was used the most, followed, in turn, by the back, enrich, and the other zones (Table 5.6 & Figure 5.4, $\chi^2 = 10.1$, df = 3, $P < 0.05$; for post-hoc analysis refer to Table 5.7). Similarly, in Phases 2, 3, 4 and 5, the edge zone was used the most, followed by the enrich and other zones, and finally by the back zone (Table 5.6 & Figure 5.4, Phase 2, $\chi^2 = 13.7$, $P < 0.01$; Phase 3, $\chi^2 = 9.6$, $P < 0.05$; Phase 4, $\chi^2 = 13.84$, $P < 0.01$; Phase 5, $\chi^2 = 11.6$, $P < 0.05$; for post-hoc analysis refer to Table A4. in Appendix 5.1). The percentage of time spent in the back zone was significantly greater in Phase 1 when compared to Phases 2 and 4 of the study (Table 5.6 & Figure 5.4,$\chi^2 = 10.6$, df = 4, $P < 0.05$; for post-hoc analysis refer to Table A4. in Appendix 5.1). Similarly, the percentage of time spent in that part of the enclosure in which furnishings were administered during the study was significantly higher during Phases 2 and 3 compared to Phases 1 and 4 of the study (Table 5.6 & Figure 5.4, $\chi^2 = 10.3$, $P < 0.05$; for post-hoc analysis refer to Table A5. in Appendix 5.1).

Table 5.6. Percentage of time spent in different enclosure zones (mean ± standard error) during the five phases of Study A

Zones	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Edge	33.3 ± 10.8	36.9 ± 9.8	36.4 ± 7.0	44.8 ± 11.0	32.2 ± 11.3
Back	25.7 ± 6.2	4.7 ± 2.4	9.3 ± 2.7	6.9 ± 2.3	10.3 ± 5.2
Enrich	21.8 ± 14.0	33.1 ± 12.4	34.7 ± 10.3	28.3 ± 12.2	36.8 ± 15.8
Other	19.2 ± 11.0	25.4 ± 6.3	19.6 ± 6.1	20.0 ± 5.5	20.6 ± 5.4

5.5.2. Study B

5.5.2.1. Behaviours performed in Phases 1 and 2

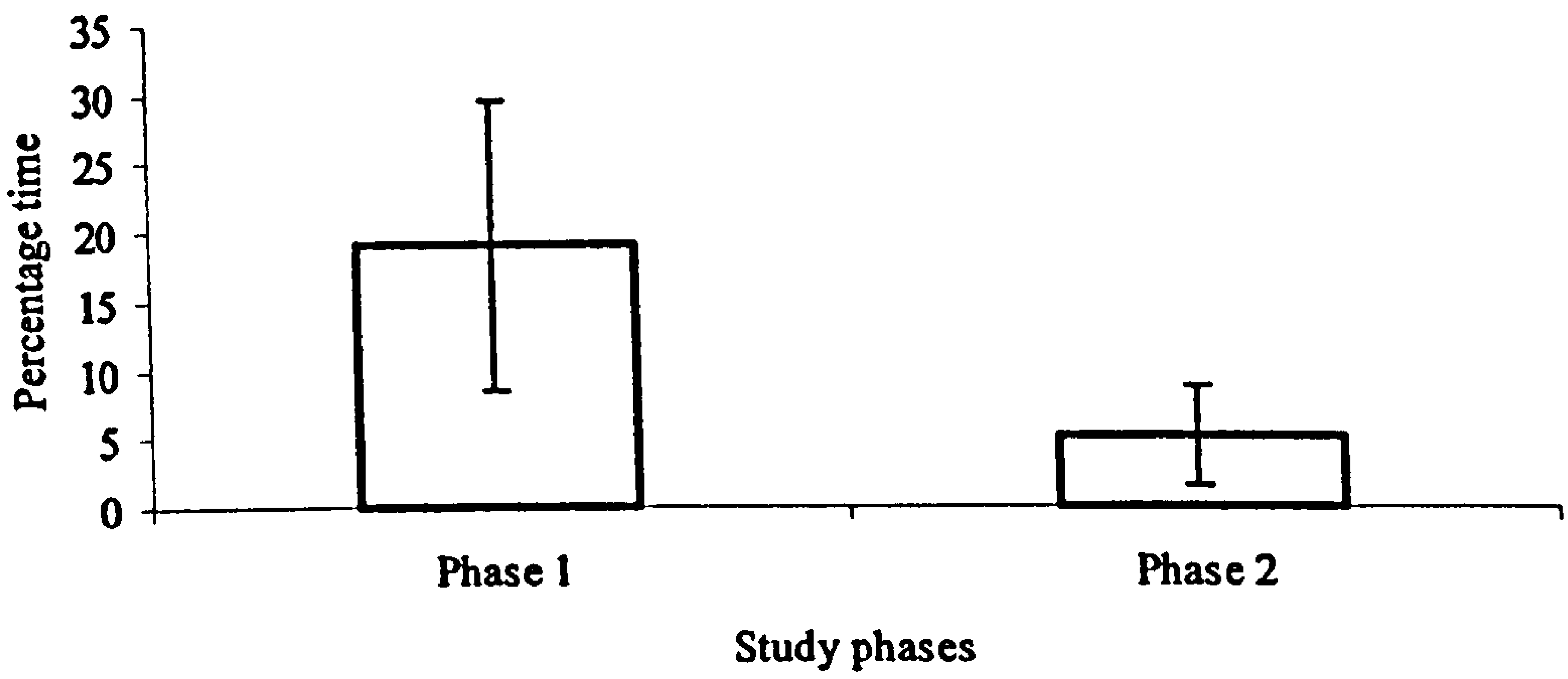
In Phase 1, a significantly greater percentage of time was spent in exhibiting resting behaviours, in comparison to active behaviours, food-related behaviours and abnormal behaviours (Table 5.7; Phase 1, $\chi^2 = 19.4$, df = 5, $P < 0.005$; for post-hoc analysis refer to Table A5. in Appendix 5.1). In Phase 2, resting behaviours were displayed the most, followed by food-related behaviours, active behaviours and abnormal behaviours (Table 5.7.; Phase 2, $\chi^2 = 22.9$, $P < 0.001$; for post-hoc analysis refer to Table A5. in Appendix 5.1). There was a significant difference in the percentage of abnormal behaviours exhibited by the animals during phases 1 and 2 of the study. Individuals exhibited significantly higher levels of abnormal behaviours during phase 1 in comparison to phase 2 of the study (Table 5.7, $Z = -2.023$, $P < 0.05$, $N = 6$). Of the behavioural events recorded during Phase 1, the frequency of affiliative behaviours was the highest, followed by abnormal, aggressive and finally reproductive behaviours; in Phase 2, in contrast, the frequency of affiliative behaviours displayed was the highest, followed by aggressive, abnormal and reproductive behaviours (Table 5.7, Phase 1, $\chi^2 = 12.0$, df = 3, $P < 0.01$; Phase 2, $\chi^2 = 7.7$, $P < 0.05$; for post-hoc analysis refer to Table A5. in Appendix 5.1).

Table 5.7. Percentage distribution of behavioural states and frequencies of behavioural events (mean ± standard error) exhibited during the two phases of Study B conducted on six captive lion-tailed macaques in Thiruvananthapuram Zoo

States	Phase I	Phase II	EVENTS	Phase I	Phase II
Abnormal	14.3 ± 7.4*	0.8 ± 2.0	Abnormal	10.5 ± 3.3	1.3 ± 0.5
Active	22.9 ± 6.8	19.2 ± 3.6	Affiliative	20.2 ± 7.5	6.7 ± 1.4
Rest	42.8 ± 6.7	31.3 ± 5.5	Aggressive	6.2 ± 3.6	9.1 ± 4.9
Food-related	20.2 ± 7.4	28.9 ± 5.4	Reproductive	0.06 ± 0.06	0.8 ± 0.4

* Sample size is six for all averages calculated in this table

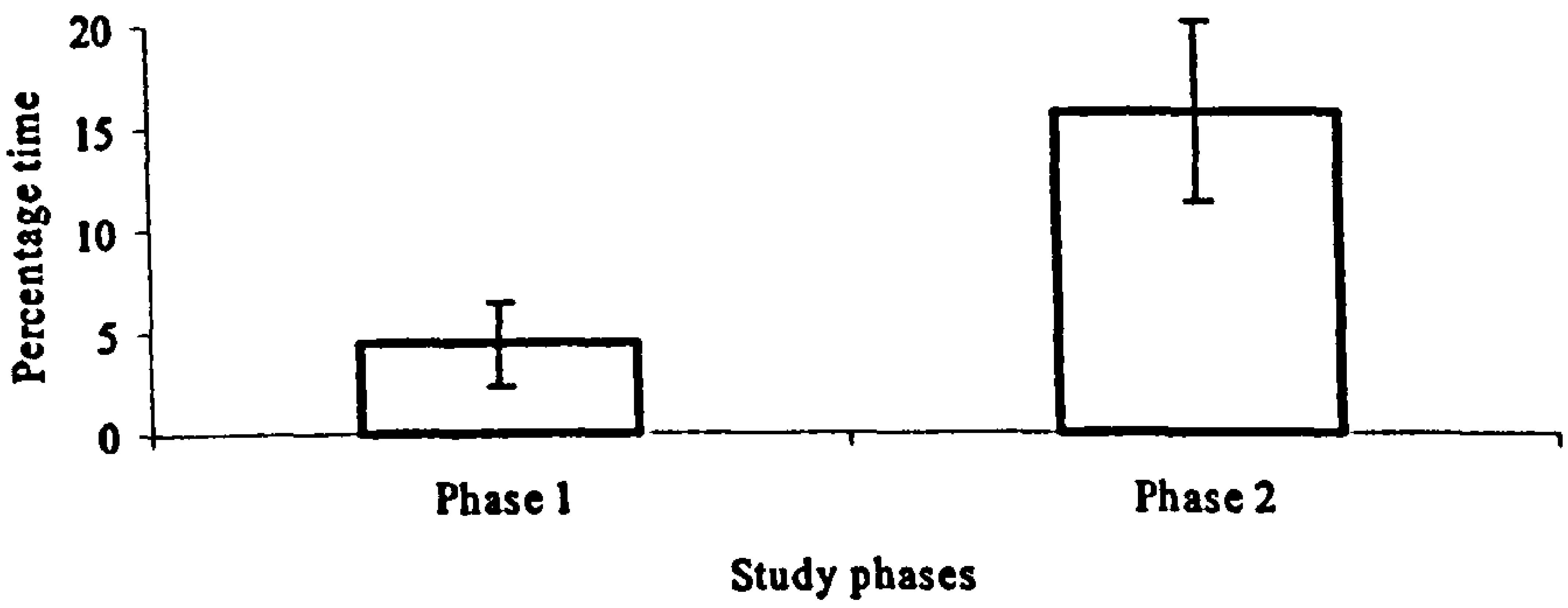
Figure 5.5 Difference in the percentage abnormal behaviour exhibited during the Study B



5.5.2.2. Effect of social enrichment on behaviour

The six captive lion-tailed macaques exhibited significantly greater levels of abnormal and feeding behaviours when they were housed singly in barren cages (Phase 1) in comparison to when they were group-housed in the complex open-moated enclosure (Figure 5.5, Phase 2; Wilcoxon's matched-pairs signed-ranks test, abnormal behaviour, $Z = -2.023$, $P < 0.05$, $N = 6$; feeding behaviour, $Z = -2.023$, $P < 0.05$). These individuals exhibited higher levels of active foraging when they were in group-housed in the open-moated enclosure than when they were housed singly in barren cages (active foraging, $Z = -2.023$, $P < 0.05$). Of the behavioural events, affiliative grunt, warning growl, abnormal and total affiliative behaviours were more frequently exhibited by the captive macaques when they were singly-housed in barren cages than when they were group-housed (affiliative grunt, $Z = -2.023$, $P < 0.05$; warning growl, $Z = -2.023$, $P < 0.05$; abnormal behaviour, $Z = -2.201$, $P < 0.05$; affiliative behaviours, $Z = -1.992$, $P < 0.05$). In contrast, the individuals exhibited significantly higher frequencies of 'move away' from other individuals when they were group-housed in comparison to when they were singly housed ($Z = -2.023$, $P < 0.05$).

Figure 5.6 Difference in the percentage active foraging behaviour exhibited during the Study B



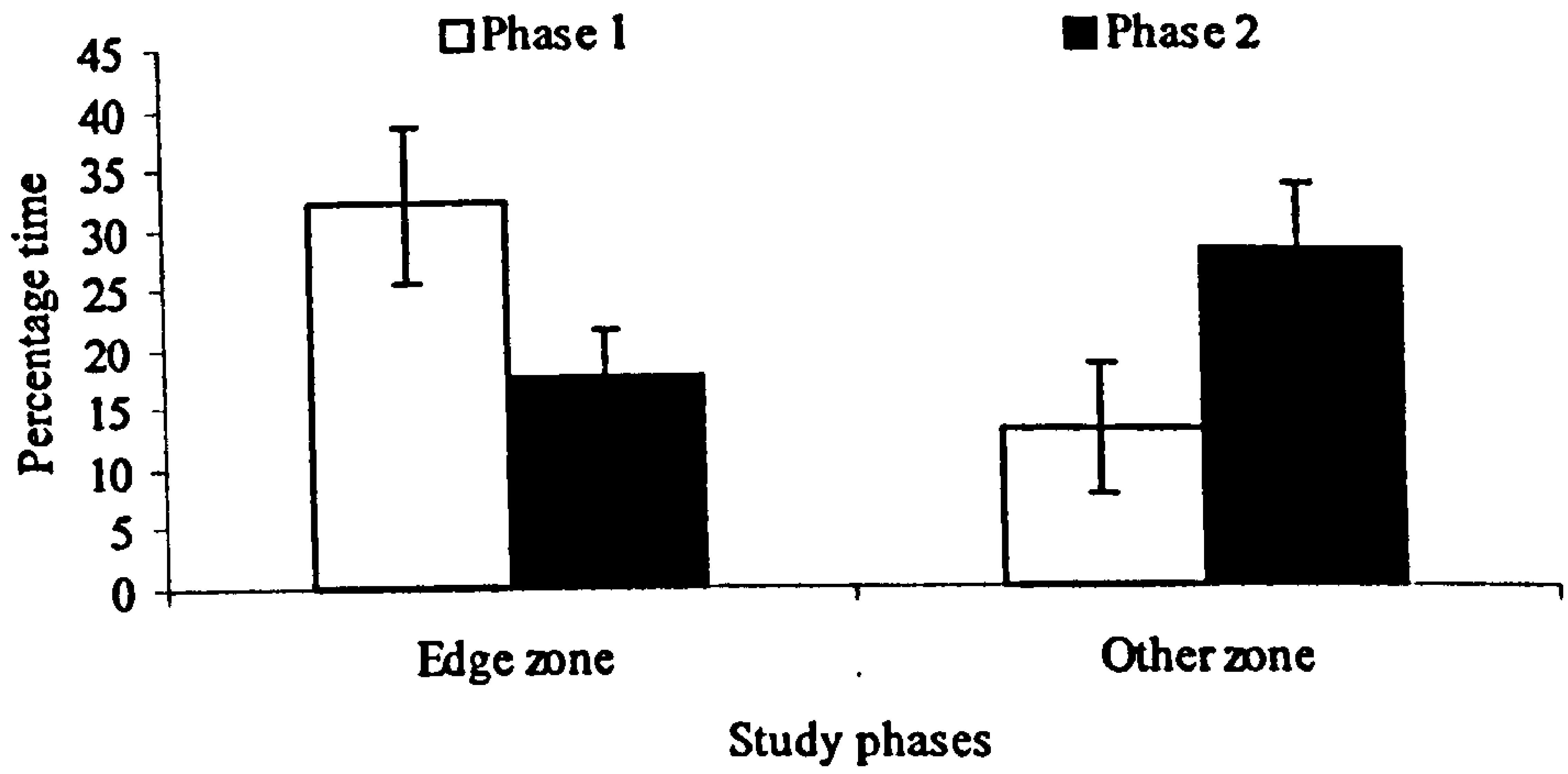
5.5.2.3. Use of enclosure space by captive lion-tailed macaques

The use of enclosure space varied during the different phases of the study. When the individuals were housed singly in barren cages, the edge zone was used the most, followed by the other, and back zones (Table 5.8, $\chi^2 = 9.33$, df = 2, $P < 0.01$; for post-hoc analysis refer to Table A6. in Appendix 5.1). There was, however, no significant difference in the percentage time spent in the four enclosure zones when the individuals were group-housed in the complex open-moated enclosure (Phase 2). Individuals spent a greater percentage of time in edge zone when they were housed in barren cages than when they were housed in the open-moated enclosure (Table 5.8 & Figure 5.7, $Z = -2.201$, $P < 0.05$). In the outdoor enclosure, lion-tailed macaques spent a significantly greater percentage of time in the other zone in comparison to when they were housed in small cages (Table 5.8 & Figure 5.7, $Z = -1.992$, $P < 0.05$).

Table 5.8. Percentage of time spent in different enclosure zones (mean ± standard error) during the two phases of Study B

Zones	Edge	Back	Enrich	Other
Phase I	68.4 ± 9.7	10.8 ± 2.4	-	10.3 ± 3.5
Phase II	14.9 ± 5.7	21.4 ± 9.8	25.9 ± 8.3	25.8 ± 4.2

5.7 Differences in utilisation of space across the different phases of Study B



5.6. DISCUSSION

The two behavioural studies were designed using different forms of enrichment techniques to determine whether they motivated singly-housed, captive lion-tailed macaques to exhibit a more naturalistic behavioural repertoire.

5.6.1 The effect of physical enrichment

In Study A, the six macaques were provided with structural as well as feeding enrichment in the form of elevated logs with ropes and a feeding basket in an attempt to stimulate active and food-related behaviours, while reducing the levels of abnormal behaviours exhibited. The results of Study A demonstrated that the individuals did exhibit active behaviours to significantly higher levels during the enrichment phase of the study (Phases 2, 3 and 4). Macaques slept more during the fifth phase. Higher levels of exploratory behaviours were also exhibited when the feeding basket was included (Phase 3). Similarly, reduced frequencies in aggressive and abnormal behaviours were observed during the enrichment phases of Study A (especially Phase 3).

During Phase 2 of this study, immediately after the cotton ropes were attached to the log placed 3 m above the ground, four of the six macaques that were studied were observed to bite these ropes aggressively. This behaviour was only observed among individuals that exhibited self-biting and abnormal behaviours during the first phase of the study. Self-biting and abnormal behaviour were both greatly reduced when enrichment was administered (especially the feeding basket in Phase 3 of the study). Self-injurious behaviours such as self-mutilation have been observed in singly-housed animals and in animals having a history of social deprivation; these abnormal traits are almost never seen in free-ranging animals or in animals housed in groups (Anderson & Chamove 1980; Chamove *et al* 1984; Shapiro *et al* 1995; Mallapur & Choudhury 2003; Mallapur in press). Scientists have suggested that self-mutilatory behaviours may be redirected social aggression when there are no social targets present (Anderson & Chamove 1980; Chamove *et al* 1984). The presence of a new object in the enclosure could have thus stimulated those macaques exhibiting self-biting to redirect their aggression to the over-hanging ropes administered as a form of enrichment.

The marked decrease in self-biting and abnormal behaviour levels exhibited during the enrichment phases (especially Phase 3) of the study was accompanied by an increase in certain more natural behaviours such as attempted swinging and exploratory behaviours. Providing captive lion-tailed macaques with an access to the vertical dimension of the enclosure through ropes and logs appeared to give them an opportunity to exhibit more species-specific behaviour such as climbing. In this study, the individuals also spent more time in the zone in which enrichment was administered during the enrichment phases of the study (especially 2 and 3). Hence, this study showed that the lion-tailed macaques not only used the enrichment administered, they also used the enclosure area in which the enrichment was administered more than they did previously. Primates are known to use the enrichment offered to them; for example orang-utans housed in enclosures with access to the vertical dimension are often found to favour higher elevations rather than the ground (Hebert & Bard 2000). In addition, other studies have shown that changing food presentation techniques could positively influence behaviour by increasing foraging and gathering behaviour (Smith *et al* 1989; Reinhardt, 1993, 1997; Buchanan-Smith 1995; Zimmerman and Feistner 1996).

5.6.2. The effect of social enrichment

During Study B, the combined use of social enrichment along with transfer to a large complex enclosure was aimed at stimulating the macaques to exhibit natural behaviour patterns. Although the social enrichment effects cannot be clearly extracted from the potentially confounding effects of the physical change, in this study too the frequencies of certain aggressive behaviours such as warning growl and abnormal behaviours decreased considerably while foraging and food-related behaviours increased. The displays of abnormal behaviours are known to reduce when primates are transferred to larger, more complex enclosures (Clarke *et al* 1982; O'Neill *et al* 1991). Even in a study of Hanuman langurs (*Presbytis entellus*) showed that by shifting the group to a naturalistic enclosure, feeding and locomotion increased whereas sleeping and aggression decreased in the study animals (Little & Sommer 2002). The new enclosure also gave the langurs the opportunity to maintain a distance from the visitors.

Macaques live in large social organisations that consist of several females with juveniles and infants and more than one male (Gupta 2001). However, the ratio of males to females in an average macaque group is closest to one in the rhesus and bonnet macaque groups and the least in the lion-tailed macaque groups (Fa & Lindburg 1996). Also, while multi-male, multi-female groups of bonnet and rhesus macaques in captivity tend to live amicably, captive lion-tailed macaques consisting of more than one adult male tend to be unstable due to infighting (*pers. obs.*). Due to these reasons, lion-tailed macaques are housed in groups consisting of several females and young with only one adult male. This had led to a surplus of males in some zoos, for example at Thiruvananthapuram Zoo the six surplus males are housed singly in small barren cages. Internationally, some zoos have volunteered to house all-male troops of polygynous primates the most popular of these being all-male troops of gorillas. Today, some zoos house the surplus of captive lion-tailed macaque males in all-male groups.

It has been suggested that housing captive animals in environments, which allow them to exhibit their species-specific behaviours, is imperative to the development social behaviours (Young 2003). Thus, by providing companions to singly-housed social species such as the lion-tailed macaques housed at Thiruvananthapuram Zoo, could provide them with the appropriate environmental stimuli to display species-specific social behaviours.

5.7. CONCLUSIONS

5.7.1. Structural Enrichment (Addition of ropes and feeding basket)

Provision of cotton ropes and a feeding basket significantly influenced the behavioural repertoire of captive lion-tailed macaques by reducing levels of abnormal behaviours. There was also a simultaneous increase in the levels of natural behaviours, including exploratory behaviours.

5.7.2. Social Enrichment (Group housing of singly-housed macaques)

Similar beneficial changes were observed when singly-housed individuals were provided with social partners. Again, in this case too, the levels of displayed abnormal behaviours reduced considerably, while natural behaviours such as foraging and social interactions increased significantly.

The two enrichment techniques tested in this study proved to positively influence the welfare of captive lion-tailed macaques. These forms of enrichment provided the appropriate environmental stimuli to motivate the study individuals to exhibit natural behaviours, while suppressing the display of abnormal behaviours. Such abnormal behaviours are popularly used as indicators of stress or poor welfare of captive primate populations.

CHAPTER VI *Visitor influence study*

CONTENTS

6.1. ABSTRACT

Several factors serve as a potential source of stress for non-human primates in captivity, one of the most important of these being the presence of visitors. To study the influence of 'visitor presence' on captive lion-tailed macaques, a behavioural study (Study A) was conducted on 30 individuals housed in eight zoos across India. The study animals were observed on 'visitor presence' days and on 'visitor absence' days. To record the long-term impact of 'visitor presence' on captive primate behaviour, another Study (Study B) following the same sampling method was conducted in which the behaviour of seven singly-housed individuals was recorded independently when 'on-exhibit' and 'off-exhibit' in enclosures of similar sizes. The results of Study A show that captive macaques exhibited lower levels of abnormal behaviour on 'visitor absence' days when compared to 'visitor presence' days. In Study B, higher levels of abnormal behaviour were displayed 'on-exhibit' including begging behaviour. In Study A, social behaviours were influenced by the presence of visitors with the study individuals exhibiting more social behaviours and in Study B, enhanced frequencies of reproductive activity on 'visitor absence' days. 'Visitor presence' was thus found to influence the behaviour of captive lion-tailed macaques in a negative way suggesting that 'visitor presence' adversely affects their welfare. Visitor disturbance can also be dealt with by making the visitors' aware about their environment. Several modern zoos worldwide contribute to the development of conservation awareness among the public through their education programmes. Indian zoos, however, have very few education programmes and their zoo/exhibit design lack creativity, leading to animals being housed in sub-optimal environments. Another study was conducted to assess the educative influence of zoo visits on their visitors at three Indian zoos - in AAZP, SCZG and TZ. Three hundred questionnaires were completed at each site, 150 questionnaires each for 'zoo visitors' and the public outside the zoo respectively. A significant percentage of both visitors (55.93%) and the 'general public' (22.4%) were found to be aware of the appearance and biology of the lion-tailed macaque, although a relatively greater percentage of visitors supported habitat protection for the species. When asked about the goals of a zoo, a significant percentage of 'zoo visitors' said that the goals of a zoo were of conservation, education and entertainment. As high as 64% of the 'zoo visitors' said that a zoo could definitely help protect wild animals. When asked if they tease or feed animals, 96% of the 'zoo visitors' said they did not, since it would disturb or even harm the animals. Overall, this study did not find any significant difference in the awareness levels of 'zoo visitors' and the 'general public' on the lion-tailed macaques' biology, behaviour and habitat. This may suggest that the zoo visit had not been educative to the 'zoo visitors'.

Key words: zoos, visitors, conservation education, lion-tailed macaque, animal welfare, India

6.2. INTRODUCTION

The most important goal of the zoo is the motivational role that it plays in educating its visitors about conservation; this is, of course, achieved only through the optimal care and welfare of their captive collection. Several modern zoos make their major contribution to primate conservation through their education programmes (Gold 1997). Over a 100 million people visit US zoos each year (Koontz 1997; Hanson 2002). These millions present zoos with the opportunity to influence public attitude, to enhance their understanding and appreciation of wildlife and to perceive the factors that threaten the survival of animals and their habitats (Caras 1995). Modern zoo conservation work, however, is not confined to the zoo premises alone. Many *in situ* programmes have been developed or financially supported by the modern zoo community. For example, the Fort Wayne Children's Zoo in Indiana, USA, has developed an interactive education and conservation action programme that encourages students to play an active role in conservation. Through their classes, they raise funds to support primate conservation in tropical countries like Indonesia (Wiese & Hutchins 1997). Similarly, the Dian Fossey Fund, which focuses its attention on the conservation of free-ranging mountain gorillas, is based in Atlanta Zoo (Wiese & Hutchins 1997). Zoos also conduct education programmes in the focus species' country of origin; this factor is extremely important for the success of reintroduction projects and other *in situ* conservation efforts (Kleiman 1986; Durrell & Mallinson 1987; Savage *et al* 1997; Stoinki *et al* 1997).

In Indian zoos, there are very few education programmes. Zoo/exhibit design used in some Indian zoos lacks creativity leading to animals being housed in sub-optimal environments. This not only conveys the wrong message to visitors but also proves stressful to the animals themselves.

For a species such as the lion-tailed macaque, which rarely interacts with humans in its natural habitat, zoo visitors could probably serve as a source of stress as has also been observed in other species of nonhuman primates in captivity (Hosey & Duck

1987; Chamove *et al* 1988; Mitchell *et al* 1991; Venugopal & Sha 1993; Birke 2002; Blaney & Wells 2004; Skyner *et al* 2004). In some cases, teasing of zoo primates by visitors influenced the behaviour of these animals (Venugopal & Sha 1993; Birke 2002; Blaney & Wells 2004; Skyner *et al* 2004). In fact, captive primates tend to be more aggressive in the presence of visitors (Glatson *et al* 1984; Chamove *et al* 1988; Mitchell *et al* 1991). Moreover, social interactions within captive groups have been observed to decrease while behavioural abnormalities levels increase during visitors' presence (Glatson *et al* 1984; Mitchell *et al* 1991; Skyner *et al* 2004). Provision of visitor barriers has also reduced levels of abnormal behaviours exhibited by captive primates (Blaney & Wells 2004). Patterns in enclosure space use are also known to change; thus, individuals in enclosures with a greater flight distances have been observed to be relatively least stressed (Anderson *et al* 2002).

To thrive in captivity, a species must adapt to the zoo environment, its ability to respond to captive conditions with behaviour from its normal repertoire depending on the degree to which the particular captive condition resembles its natural environment (Carlstead & Shepherdson 1994). The presence of certain types of abnormal behaviours in an individual's behavioural repertoire, for example, usually indicates that the individual is housed in an atypical environment and is under stress (Chamove *et al* 1988; Mason 1991; Fritz *et al* 1992; Marriner & Drickamer 1994; Mootnick & Baker 1994).

Lion-tailed macaques have been observed to exhibit several types of abnormal behaviours in captivity (Marriner & Drickamer 1994; Mallapur & Choudhury 2003; Mallapur in press) of which some behavioural patterns were specifically exhibited to visitors (Mallapur *pers. obs.*). There are no studies on the effect of visitor presence on the behaviour and welfare of captive lion-tailed macaques in Indian zoos or on the perceptions and awareness levels of the people visiting these zoos. In this chapter, the behaviour of captive lion-tailed macaques has been recorded in the presence and absence of visitors in order to record their influence on the behavioural repertoire and the welfare of this species in captivity. The educative influence of a zoo visit on its 'zoo visitors' in three cities in southern India has also been assessed in this study. This was achieved by specifically examining whether the zoo conservation awareness programmes addressed issues about rainforests along the Western Ghats and if the lion-tailed macaque exhibits at these zoos had educated the public about the animals' habitat and its conservation significance.

6.3. AIM

The aims of this chapter were

1. To study the influence of visitor presence of the behaviour of captive lion-tailed macaques housed in Indian zoos.
2. To investigate whether the study zoos had an educative influence on the zoo visitors.

6.4. METHODOLOGY

6.4.1. Study 1: visitor influence study

6.4.1.1. General methods

Study 1A was conducted on 30 lion-tailed macaques (15 groups) housed in eight zoos (Table 6.1). Individuals were observed on 'visitor presence' days (days when visitors were present) and on 'visitor absence' days (zoo holidays when visitors were absent). Individuals from all age, sex and rearing history categories were observed and were housed in enclosures of varying size and complexities (refer to ranks in Table 2.1 and Section 2.4 *Data Analysis* in Chapter II *General Methods*).

Study 1B was conducted on seven singly-housed captive lion-tailed macaques housed in TZ Zoo, one of the eight zoos where Study 1A was conducted. The behaviour of these seven individuals was first recorded when they were housed singly in 'on-exhibit' enclosures (enclosures in which the lion-tailed macaques were displayed to the visiting public). These animals (six males and one female) were also observed when they were housed singly in 'off-exhibit' enclosures (enclosures housing lion-tailed macaques which were not on display to the visiting public) of similar-size to the on-exhibit enclosures. In Study 1B, the behaviour of each individual was only recorded on 'visitor presence' days but not on 'visitor absence' days. The feeding time and the time at which the animal keepers cleaned the enclosures varied across zoos (refer to feeding and keeper cleaning schedules in Table 2.2 and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*). The diet charts also varied considerably across zoos as well (refer to diet charts Table 2.3 and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*).

Table 6.1. Lion-tailed macaque groups on which the influence of visitor presence was observed across eight Indian zoos

Zoo[1]	Visitor distance[2]	Number of lion-tailed macaques studied		Enclosure features
	(in metres)	Group composition[3]	Total group size[4]	
AAZP	1.5	1:1:2[5], 1:0:1	6 (2:1:3)	Cage[5]; wet moat; rest cages
JZ	1.5	1:1:1	3 (1:1:1)	Wet moat
MCZP	1.5	2:0:0	2 (2:0:0)	Wet moat
MBZ	1.5	1:0:0, 1:0:0, 0:1:1	4 (2:1:1)	All cages
NZP	1.5	1:1:0	2 (1:1:0)	Cage
PZ	0.0	1:2:0	3 (1:2:0)	Wet moat
SMZ	1.5	1:0:0, 1:0:0, 1:0:0	3 (3:0:0)	All cages
TZ	2.4	1:4:0, 1:0:0, 1:0:0	7 (3:4:0)	Dry moat; all others cages

[1] The full names of the zoos have been mentioned in the text (see section 2.1.1.).
[2] Measured as the distance between the outermost barrier-edge of the lion-tailed macaque exhibit to the closest visitor-access point
[3] Refers to the number of sexually mature males: sexually mature females: young (infants and juveniles).
[4] The composition of groups housed separately at each zoo has been included in brackets.
[5] The type of enclosure housing each group in each zoo has been given in the same order. Refer to definitions for enclosure features in the text (see section 2.1.4.*Enclosure Details* in Chapter II *General Methods*).

Study 1A: The study commenced in June 2002 and ended in December 2002. A period ranging from seven to 10 days was spent at each zoo during the study. The time spent at each zoo depended on the number of lion-tailed macaques housed in that zoo. The study was conducted at the following zoos:

1. Arignar Anna Zoological Park (AAZP), Vandalur, Tamil Nadu state
2. Jaipur Zoo (JZ), Jaipur, Rajasthan state
3. Mahendra Chaudhury Zoological Park (MCZP), Chandigarh, Punjab state
4. Maitri Baagh Zoo (MBZ), Bhilai, Chhattisgarh state

5. National Zoological Park (NZP), New Delhi, Delhi state
6. Patna Zoo (PZ), Patna, Bihar state
7. State Museum and Zoo (SMZ), Thrissur, Kerala state
8. Thiruvananthapuram Zoo (TZ), Thiruvananthapuram, Kerala state

The lion-tailed macaques were observed for a period of nine hours during the day between the time the zoo opened in the morning, at 0830 h until the time it closed at 1730 h. Sampling was conducted on

1. *'Visitor presence' days:* Each macaque was observed over three control days (for groups sizes, see Table 6.1). The second and third days were pseudo-replicates of the first. Each individual was studied for approximately a total of 5.6 ± 0.04 hours (N (sample size) = 30). A total of 168 hours was thus spent observing captive lion-tailed macaques on 'visitor presence' days.

2. *'Visitor absence' day:* each macaque was observed over one day in the 'on-exhibit' enclosure when the zoo was closed to the public (for groups sizes, see Table 6.1). Each individual was studied for approximately 1.6 ± 0.3 hours (N = 30) during visitor's absence. A total of 47.6 hours were thus spent observing captive lion-tailed macaques on visitor absence days respectively.

However, since 'visitor absence' days occurred once a week, the study animals were observed for a greater number of hours per individual on 'visitor presence' days. Due to the short observation periods per individual on 'visitor absence' days, opportunities to observe and record rare behaviours such as mating, staccato call or certain abnormal behaviours could have been reduced.

Study 1B: This study was conducted on seven captive lion-tailed macaques housed at TZ Zoo. All seven were permanently housed singly 'on-exhibit' before and during the first phase of the study. These individuals (six males and one female) were also studied 'off-exhibit' where they were maintained singly. The cages housing all animals 'on-' and 'off-exhibit' were ≤ 25 m2 in area and barren with no enclosure furnishings. All seven individuals were confiscated from small, unrecognised zoos, private owners and circuses. The behaviour was recorded in two stages:

1. Singly-housed 'on-exhibit': the behaviour of each individual was recorded when they were housed singly in their 'on-exhibit' cages. Individuals were, however, housed in neighbouring enclosures and hence could maintain both visual and physical contact with one another.
2. Singly-housed 'off-exhibit': the same individuals were studied again three months after their transfer to 'off-exhibit' enclosures and their behaviour recorded. Individuals were, however, housed in neighbouring enclosures and hence could maintain both visual and physical contact with one another.

All enclosures on- and off-exhibit were barren cages of < 50 m^2 in size (refer to Chapter II *General Methods* for definitions of 'barren', 'cage' and enclosure sizes). The animals were fed at 1230 h and 1600 h by scattering the food on the enclosure floor. The keepers cleaned the enclosures every morning between 0900 h and 1000 h. The individuals were housed next to one another, when they were on- and off-exhibit so that they would see, smell and touch one another.

Observations were conducted between February and October 2003. In the study, the lion-tailed macaques were observed for a period of five hours during the day between the time the zoo opened in the morning at 0830 h to the time it closed at 1730 h. Each individual was studied for approximately a total of 5.1 ± 1.0 h (N = 7) 'on-exhibit' and a total of 5.4 ± 1.0 h (N = 7) 'off-exhibit'.

6.4.1.2. Behavioural sampling

During both Studies 1A and 1B, a combination of focal animal sampling and instantaneous scanning was used to quantify the behaviour displayed by the captive macaques (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). Each behavioural sampling session was initiated with an instantaneous scan, and was followed by a focal animal sample of one of the individuals in the group for a duration of 15 min (refer to Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*).

6.4.1.3. Space Use

The use of enclosure space by captive lion-tailed macaques was recorded during the instantaneous scans conducted to record the behavioural states (refer to Section 2.3 *Space Use* in Chapter II *General Methods*).

6.4.2 General Methods - Study 2: visitor perception study

The study was conducted in three study sites:

1. Shri Chamarajendra Zoological Gardens, Mysore, Karnataka (SCZG)
2. Arignar Anna Zoological Park, Vandalur, Tamil Nadu (AAZP)
3. Thiruvananthapuram Zoo, Thiruvananthapuram, Kerala (TZ)

These three zoos were specifically chosen because they had an existing education programme and because they maintained their lion-tailed macaques in species-appropriate groupings in large, naturalistic enclosures. This study was conducted between November 2003 and January 2004.

6.4.2.1. Questionnaire design

A questionnaire survey for 'zoo visitors' (public visiting the three study zoos) and the 'general public' (people who were randomly sampled from various parts of the cities in which the three study zoos were located) was conducted to assess the level of awareness of conservation-related issues among the public. The questionnaire consisted of a combination of closed and open-ended questions, and some of the closed questions were ranked so as to be able to rate the visitor perception information from one zoo in comparison to the other zoos

(<http://www.statpac.com/surveys/>, 15/8/2003). The visitor perception questionnaire consisted on 15 questions while the public questionnaire consisted of eight. Of these, six questions were similar in the two questionnaires. A research assistant in each city interviewed the visitors and the public in regional languages (Plate 6.1). The assistants filled in 150 questionnaires each for 'zoo visitors' and the 'general public' by randomly sampling them at the zoo exit and at the city centre respectively. Hence, although the six questions were worded differently in English, it should not affect the validity of the comparison (between zoo visitors and the general public) because the research assistants translated these questions in the regional languages (Malayalam in Thiruvananthupuram, Tamil in Chennai and Kannada in Mysore) when they conducted the survey. These assistants filled in the questionnaires for each visitor to avoid problems related to literacy and language barriers. One questionnaire was filled in for each group of 'zoo visitors' or the 'general public' questioned. This method was adopted so as to minimise the chance of receiving identical answers on questionnaires filled in for members from the same group.

Plate 6.1 Researcher filling in a questionnaire for visitors at TZ

6.4.3. Data analyses

6.4.3.1. Study 1: visitor influence study

The display of behavioural states, as recorded in the instantaneous scans, has been expressed as a percentage of the total time that an individual was observed. The frequencies of behavioural events, as recorded by focal animal sampling, have been expressed as number of events or acts per hour. Behaviour and space use data for different individuals in each group were also pooled at the end of the observation period to obtain group averages (refer to Section 2.4 *Data Analysis* in Chapter II *General Methods*). Since the behavioural and space use data recorded was not normally distributed and since the degree of variance was high, non-parametric statistics was used for data analyses. The Friedman's two-way analysis of variance test was used to analyse differences across the different behavioural categories and enclosure zones, in both Studies 1A and 1B (refer to Section 2.4 *Data Analysis* in Chapter II *General Methods*; Siegel & Castellan 1988). The Wilcoxon signed ranks test was used to test for any differences in the performance of behaviours between visitor presence and absence in Study 1A and to test for differences in an individual's behaviour when housed 'on-exhibit' and 'off-exhibit' in Study 1B (refer to Section 2.4 *Data Analysis* in Chapter II *General Methods*; Siegel & Castellan 1988). All P values that have been reported are two-tailed. SPSS (Version 7.5) was used to conduct all the statistical tests.

6.4.3.2. Study 2: visitor perception study

The data obtained from six questions in the questionnaires (questions 5 to 9 in the visitor perception study, refer to Appendix 6.2; questions 2 to 7 in the public perception study, refer to Appendix 6.3) used for the 'general public' were employed as control for the data obtained from the questionnaires for the 'zoo visitors'. This was done in order to assess if the zoo visit had made the visitors more aware of the endangered status of lion-tailed macaques, their welfare in captivity, their rainforest habitat in the wild and the need to conserve such habitats. If a greater percentage of zoo visitors answered correctly on four of the six questions (66.67% of the questions) then it could be considered to have an educative influence on its visitors. However, it must be noted that those (zoo visitors or the general public) who have either seen a lion-tailed macaque on television or have read an article about the species, could be more likely to answer the questions correctly. Demographic details of the zoo visitors was analysed only for TZ and AAZP since the data were incorrectly filled in for SCZG. The data were also compared across the three cities (Thiruvananthapuram, Chennai and Mysore). The data obtained through questionnaire surveys being nominal, frequencies, ratios and percentages have primarily been used to represent the results of this analysis. The Chi-Square test for two independent samples was used to compare the differences in the reports from questionnaires filled in for the 'zoo visitors' and the 'general public' (Siegel & Castellan 1988). The Chi-Square test for K independent samples was used to compare the differences in the reports from questionnaires filled in Thiruvananthapuram, Chennai and Mysore. All P values that have been reported are two-tailed.

6.5. RESULTS

6.5.1. Study 1A: visitor influence study

6.5.1.1. Influence of 'visitor presence' on behaviour

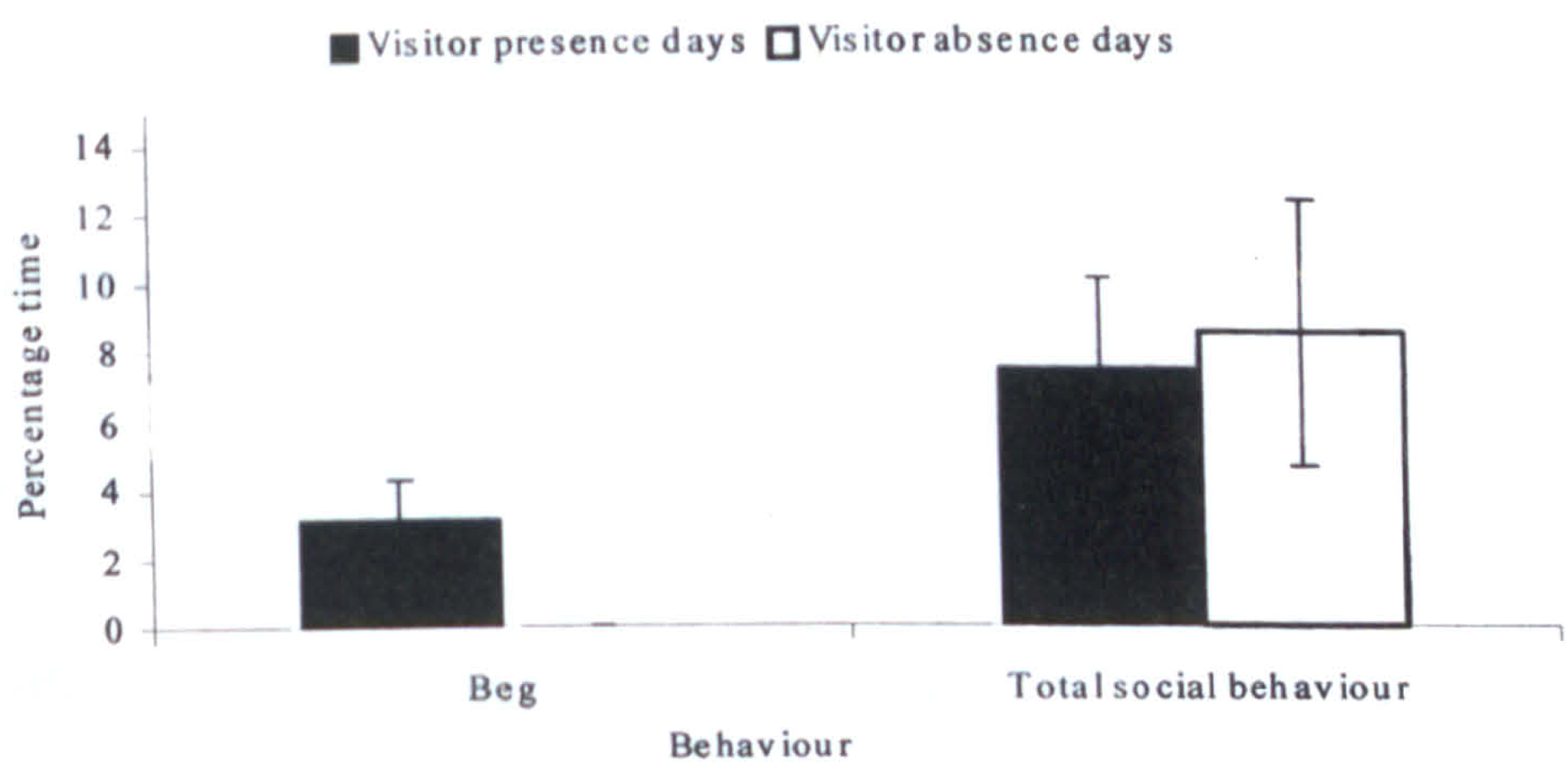
The captive lion-tailed macaques spent a significantly greater percentage of time in exhibiting resting behaviour compared to active behaviours, food-related behaviours, social behaviours and abnormal behaviours, both on 'visitor absence' days as well as on 'visitor presence' days (Friedman's Test, 'visitor absence' days, $\chi2 = 81.4$, $df = 4$, $P < 0.001$, $N = 15$ (number of lion-tailed macaque pairs/groups); 'visitor presence' days, $\chi2 = 91.5$, $P < 0.001$; for post-hoc analysis refer to Table A1 in Appendix 6.1). By contrast, the frequencies of behavioural categories differed between 'visitor absence' and 'visitor presence' days. On days when visitors were present, frequencies of aggressive behaviours were the highest (Plate 6.2), followed by affiliative behaviours, abnormal behaviours and finally, reproductive behaviours; on 'visitor absence' days, however, aggressive behaviours occurred most followed by affiliative behaviours, reproductive behaviours and abnormal behaviours ('visitor absence' days, $\chi2 = 30.8$, df = 3, $P < 0.0001$, N = 15; 'visitor presence' days, $\chi2 = 39.9$, $P < 0.0001$; for post-hoc analysis refer to Table A2 in Appendix 6.1).

Plate 6.2 A male lion-tailed macaque displays 'eye-flash' towards observer at Patna Zoo

The study individuals exhibited significantly greater levels of total social behaviours (Allogroom, mate, suckle and play, refer Table 4.1 in Chapter IV) on 'visitor absence' days than on 'visitor presence' days ($Z = -2.242$, N = 15, $P < 0.05$). Similarly, the frequencies of reproductive behaviours significantly lower during 'visitor presence' days than on 'visitor absence' days (biting, $Z = -1.962$, $P < 0.05$, N= 29 (number of lion-tailed macaque individuals); yawning, $Z = -2.099$, $P < 0.05$; reproductive behaviours, $Z = -2.604$, $P = 0.01$). Aggressive bite was only exhibited by males (6.5 ± 2.3 event/h, N = 2) towards the females in their group on 'visitor presence' days.

Plate 6.3 Visitor feeding lion-tailed macaque at Maitri Baagh Zoo, Bhilai

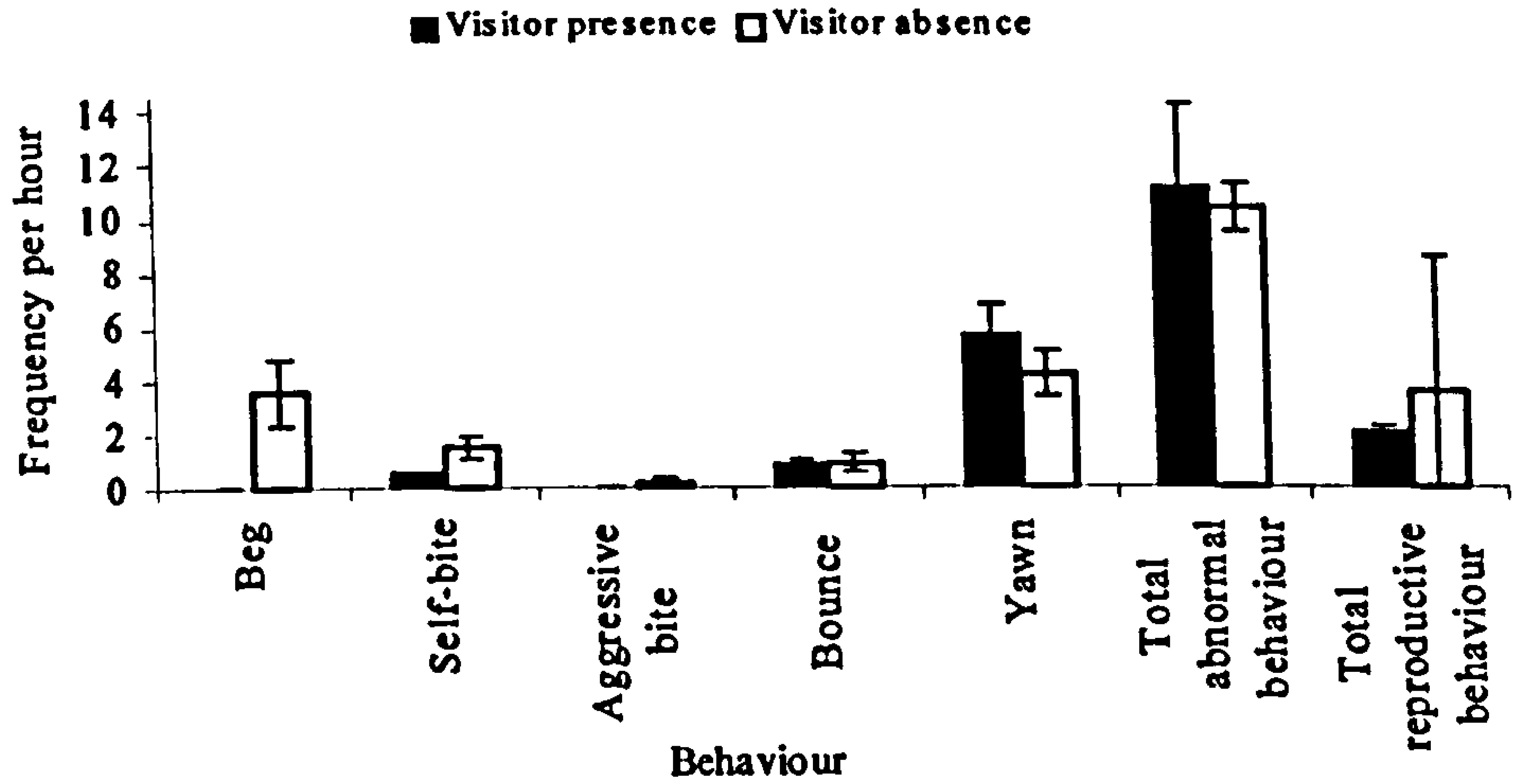
Figure 6.1 Influence of visitor presence on the percentage begging and social behaviour exhibited by captive lion-tailed macaques [Study 1A]



6.5.1.2. Influence of 'visitor presence' on abnormal behaviour

Begging durations were only exhibited on 'visitor presence' days and not on 'visitor absence' days (Figure 6.1, 2.9 ± 1.04, $N = 13$). The frequencies of abnormal behaviour, self-biting, begging (Plate 6.3) and bouncing were also significantly higher on 'visitor presence' days than on 'visitor absence' days (Wilcoxon signed ranks test, abnormal behaviours, Z= -2.223, P < 0.05, N= 30; self-biting, Z= -2.023, P < 0.05; begging, Z= -2.197, P < 0.05; bouncing, Z= -2.521, P < 0.05).

Figure 6.2 Influence of visitor presence on the frequencies of behaviour exhibited by captive lion-tailed macaques [Study 1A]



6.5.1.4. Influence of 'visitor presence' on use of enclosure space

There was no significant difference in the proportion of time spent in the edge, enrich and other zones on 'visitor absence' days and on 'visitor presence' days. The back zone was, however, used significantly less when visitors were present than when they were absent (Back zone, Z = -2.793, P < 0.05, N= 30).

6.5.2. Study 1B: visitor influence study

6.5.2.1. Influence of 'visitor presence' on behaviour

There was a significant difference in the proportion of time spent exhibiting resting, active, food-related, abnormal and social behaviours. The study individuals spent a significantly greater percentage of time in resting behaviours, followed, in decreasing order of time spent in them, by active behaviours, food-related behaviours, abnormal behaviours and social behaviours (Friedman's Test, $\chi2$ = 23.3, df = 4, P < 0.001, N = 7 (number of lion-tailed macaque individuals); for post-hoc analysis refer to Table A3 in Appendix 6.1). When they were housed 'on-exhibit', resting behaviour was again exhibited the most, followed by active behaviours, abnormal behaviours, food-related behaviours and social behaviours ($\chi 2 = 19.7$, $P < 0.005$; for post-hoc analysis refer to Table A3 in Appendix 6.1). Of the behavioural events recorded for these individuals 'off-exhibit', the frequencies of affiliative behaviours exhibited were most frequently, followed by abnormal, aggressive and finally reproductive behaviours ($\chi 2 = 7.9$, df = 3, $P < 0.05$; for post-hoc analysis refer to Table A4 in Appendix 6.1). In the 'on-exhibit' enclosures, the frequencies of aggressive behaviour exhibited were the highest, followed by abnormal, affiliative and reproductive behaviours ($\chi 2 = 10.4$, $P < 0.05$; for post-hoc analysis refer to Table A4 in Appendix 6.1).

Individuals exhibited significantly higher frequencies of total aggressive behaviours (refer to behavioural events Section 2.2.3 Aggressive behaviours in Table 4.1 in Chapter IV) and yawning 'on-exhibit' than when housed 'off-exhibit' (Figure 6.3, aggressive behaviours, $Z = -2.366$, $P < 0.05$; yawning, $Z = -2.366$, $P < 0.05$).

Figure 6.3 Influence of visitor presence on the frequencies of behaviour exhibited by captive lion-tailed macaques [Study 1B]

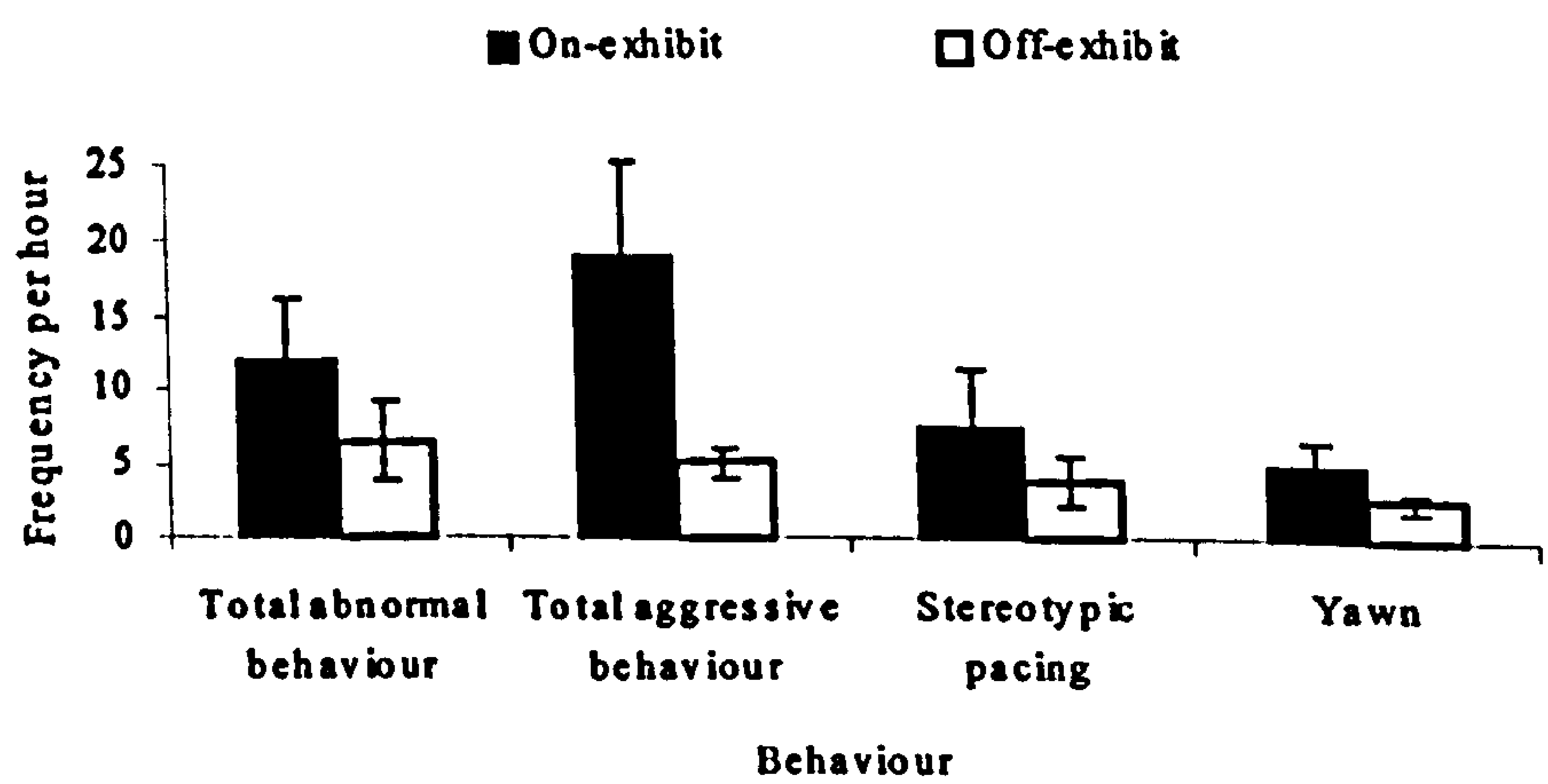
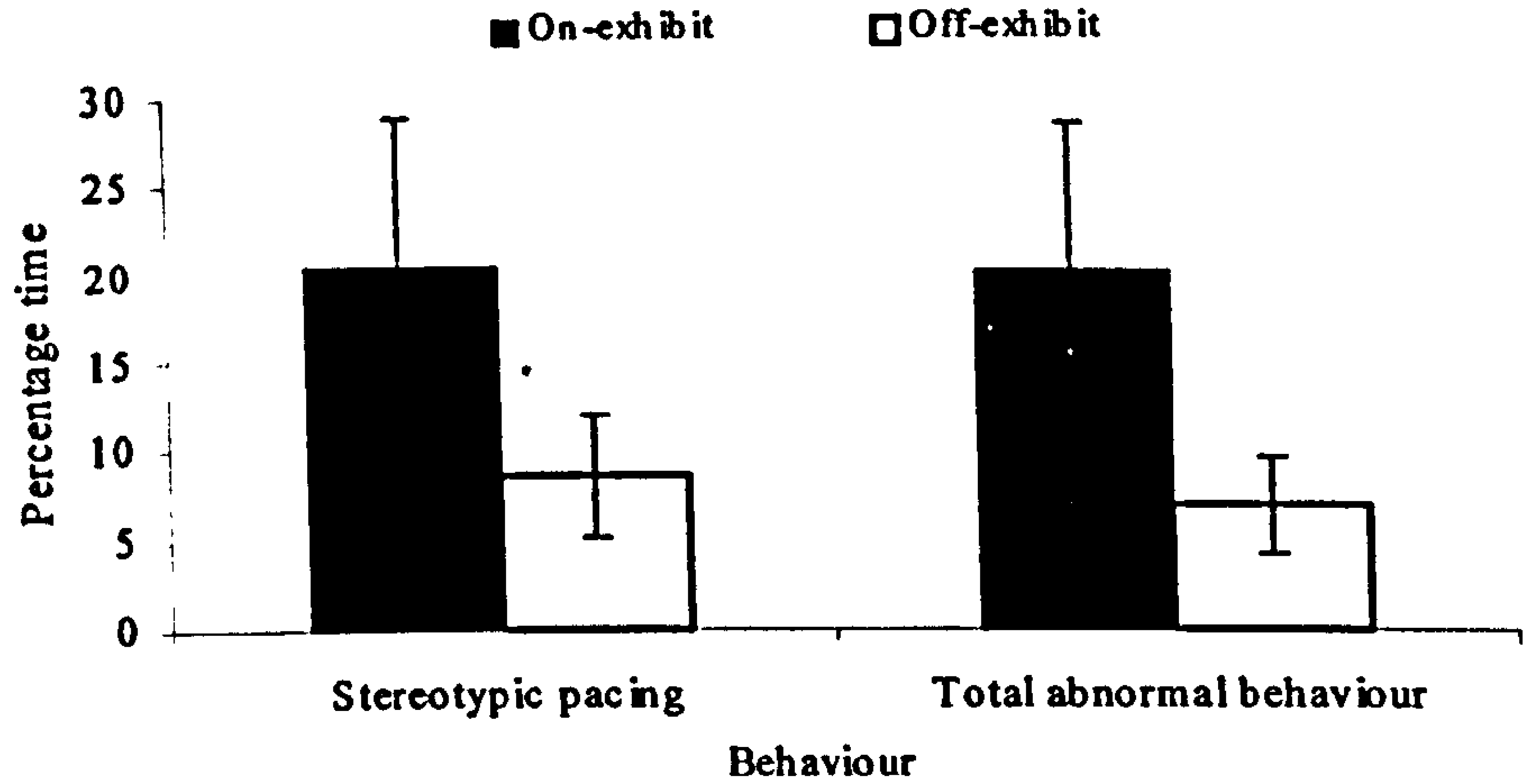


Figure 6.4 Influence of visitor presence on the percentage of stereotypic pacing and total abnormal behaviour by captive lion-tailed macaques [Study 1B]



6.5.2.2. Influence of 'visitor presence' on abnormal behaviours

The individuals displayed higher levels of abnormal behaviour and stereotypic pacing when housed 'on-exhibit' than when they were housed 'off-exhibit' (Figure 6.4, Wilcoxon's matched-pairs signed-ranks test, abnormal behaviour, $Z = -2.023$, $N = 7$ (number of lion-tailed macaque individuals), $P < 0.05$; stereotypic pacing, $Z = -2.023$, $P < 0.05$). Similarly, individuals exhibited significantly higher frequencies of abnormal behaviours, and stereotypic pacing 'on-exhibit' than when housed 'off-exhibit' (Figure 6.4, abnormal behaviours, $Z = -2.028$, $P < 0.05$; stereotypic pacing, $Z = -2.366$, $P < 0.05$).

6.5.2.3. Influence of 'visitor presence' on use of enclosure space

The use of enclosure space differed 'on-' and 'off-exhibit'. While housed 'on-exhibit', the edge of the cages was used the most, followed by the other, back and enrich zones (Friedman's Test, $\chi 2 = 13.0$, $df = 3$, $P < 0.01$; for post-hoc analysis refer to Table A5 in Appendix 6.1). There was no significant difference in the utilisation of space 'off-exhibit'. The enrich zone was utilised significantly more by individual macaques when they were 'off-exhibit' than when 'on-exhibit' (Wilcoxon Sign Rank Test, $Z = -2.366$, $P < 0.05$).

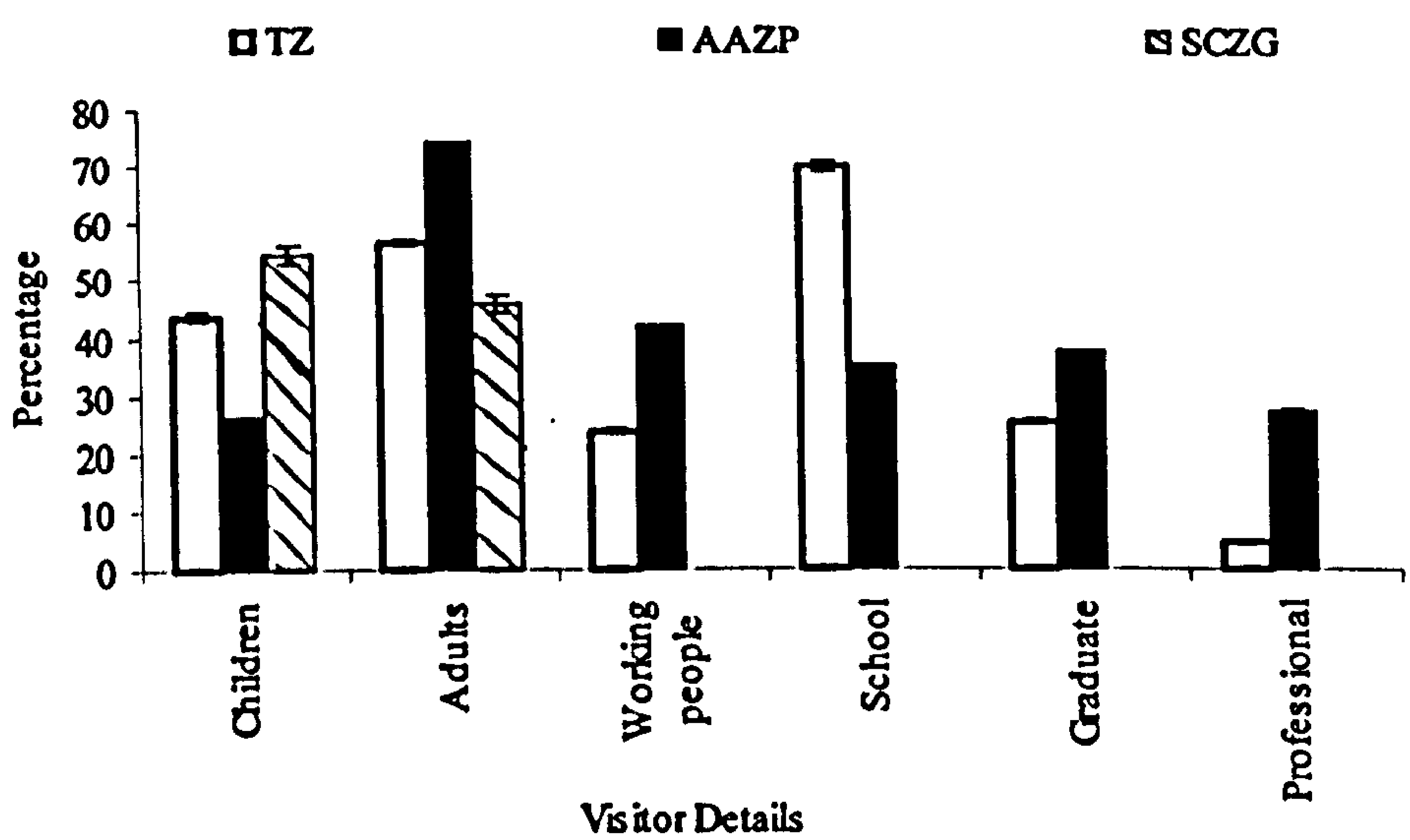
6.5.3. Study 2: visitor perception study

The results of this study were analysed from a total of 413 zoo visitor questionnaires (TZ - 150, AAZP - 137, SCZG - 126) and 450 questionnaires filled in by the 'general public' (150 each in each city).

Table 6.2. Percentages of 'zoo visitors' who rated their zoo visit being recreational or educational across the three study zoos

	TZ	AAZP	SCZG
Sample size	150	137	126
Recreational only (%)	35.81	37.96	6.98
Educational only (%)	7.43	0.00	27.91
Both (%)	53.38	60.58	65.12
Neither (%)	3.38	1.46	0.00

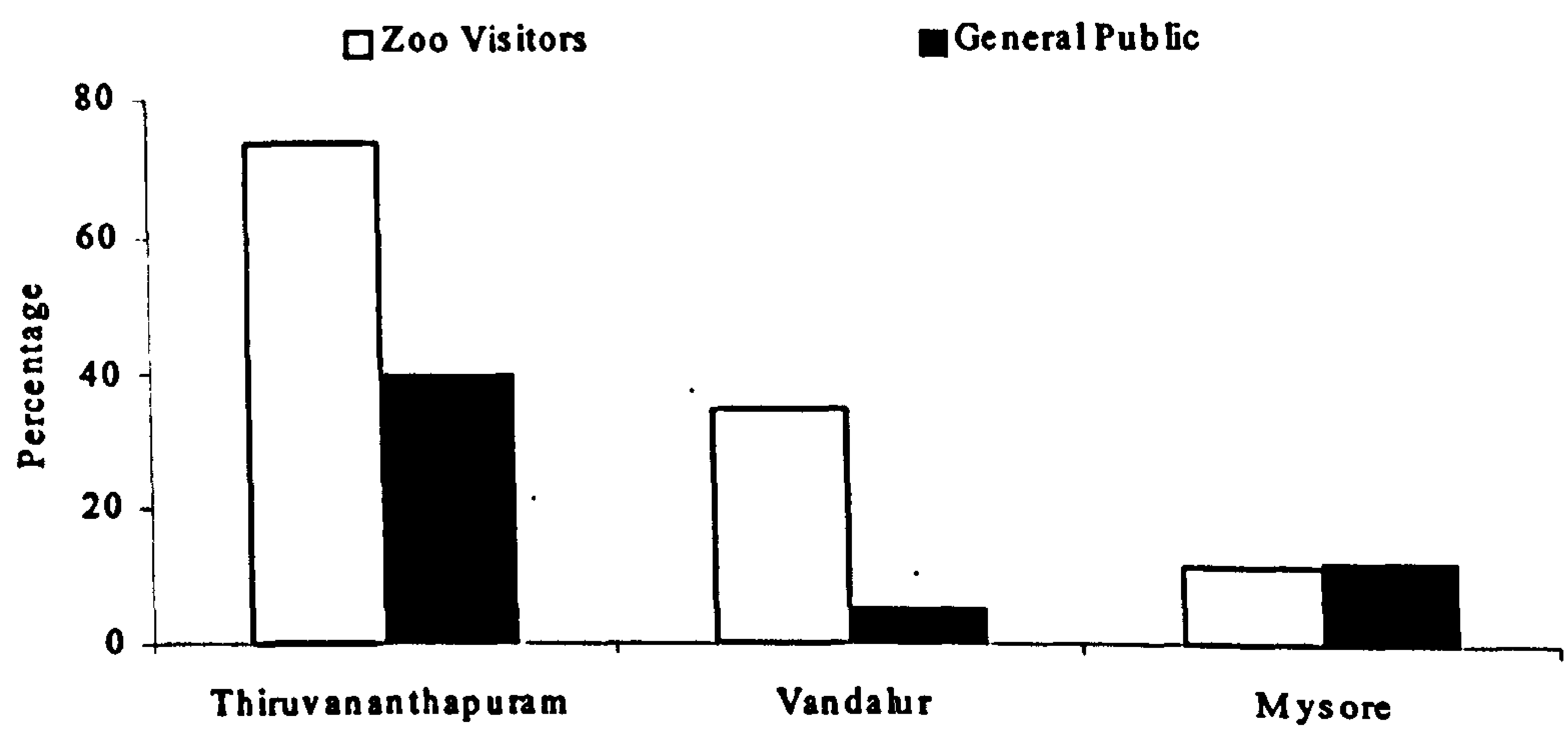
Figure 6.5 Demographic details of zoo visitors for three zoos in southern India



6.5.3.1. Demography of the 'zoo visitors' sampled

The demographic profile of the visitors sampled at the three study zoos is shown in Figure 6.5 and Table 6.2. The percentage of adults and children visiting these zoos were significantly different with 54.4% and 43.4% of the zoo visitors being children (ten to fifteen years of age) at SCZG and TZ respectively, while only 25.9% were children in AAZP (chi-square test, $\chi2 = 130.3$, df = 2, $P < 0.001$, N = 3279 (number of 'zoo visitors')). There was also a significant difference between TZ and AAZP in the educational background of the 'zoo visitors'. While 59.16% of the 'zoo visitors' at TZ claimed to have either completed or were completing primary education, only 27.37% in AAZP did so (Figure 6.5; $\chi2 = 152.37$, df = 1, $P < 0.001$, N = 1310). As high as 59.85% of the 'zoo visitors' at TZ said that they had visited the zoo before while 65.13% at AAZP said they had not ($\chi2 = 213.28$, df = 2, $P < 0.001$, N = 398).

Figure 6.6 Percentage of zoo visitors and general public who described the lion-tailed macaque correctly across three zoos

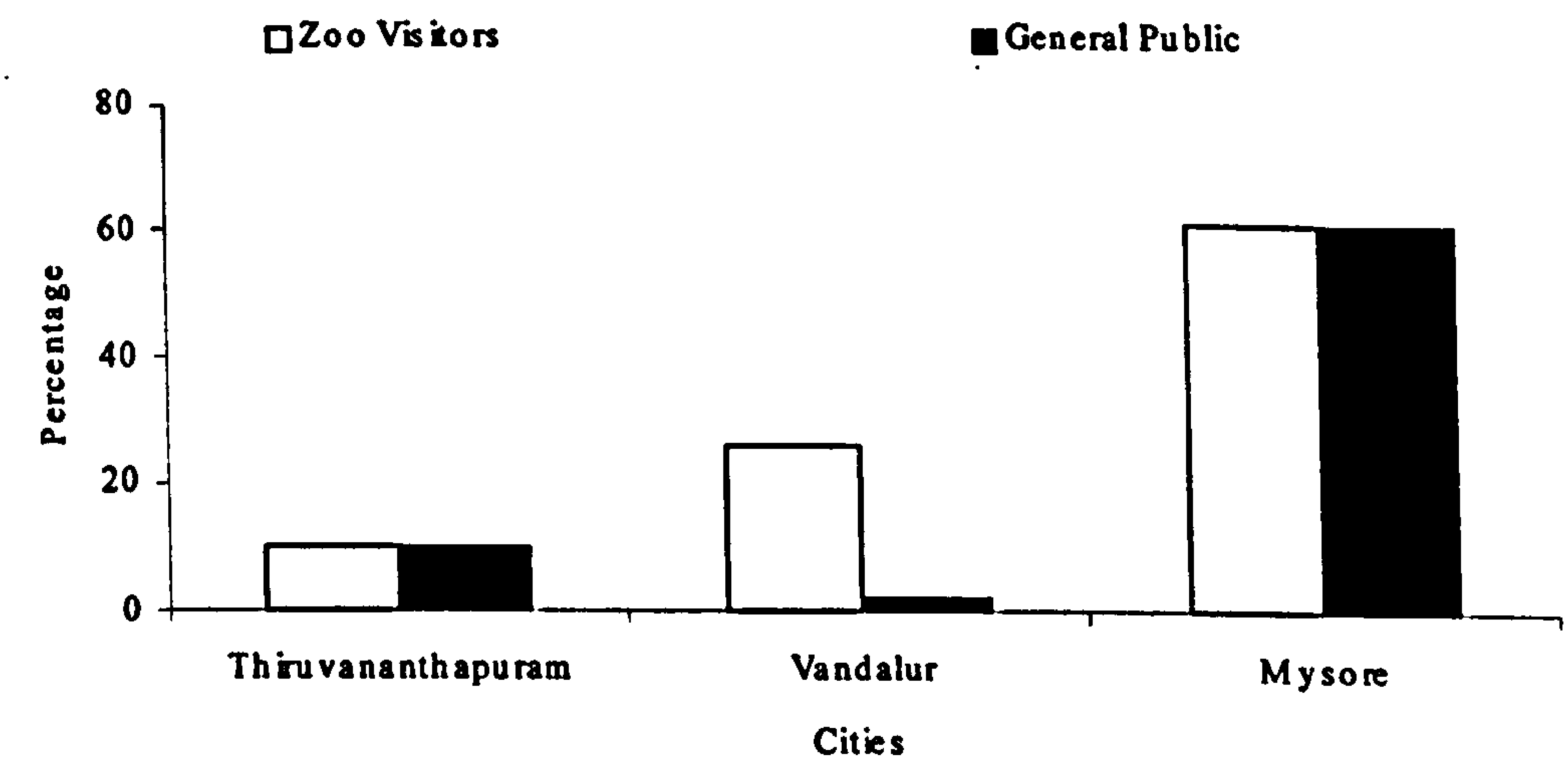


6.5.3.2. Welfare and conservation awareness of the 'zoo visitors'

i. Awareness of the lion-tailed macaques' biology and behaviour

There are no significant differences between people ('zoo visitors' and the 'general public') across the three cities (percent of people who reported seeing the lion-tailed macaque, in Thiruvananthapuram = 84.3 ± 1.0, Mysore = 41.2 ± 2.5, Chennai = 61.8 ± 12.5) who had or had not seen the lion-tailed macaque. Similarly, there was no significant difference between the 'zoo visitors' (percent who reported seeing the lion-tailed macaque = 67.8 ± 12.5) and the 'general public' (percent who reported seeing the lion-tailed macaque = 57.0 ± 13.4) in this regard. When asked to describe the lion-tailed macaque, there was a significant difference found across cities, with a greater number of people at Thiruvananthapuram answering correctly in comparison to people from Mysore and AAZP (Figure 6.6, $\chi2 = 33.04$, df = 2, $P < 0.001$, N = 256 (number of questionnaires filled in)). A similar difference was noted between 'zoo visitors' and the 'general public' in all three cities, with a greater percentage of 'zoo visitors' knowing what the lion-tailed macaque looked like (Figure 6.6, $\chi2 = 15.77$, df = 1, $P < 0.001$, N = 256). When asked the question whether free-ranging lion-tailed macaques lived in groups or not, the answers differed significantly across zoos and between 'zoo visitors' and the 'general public'. SCZG accounted for the greatest percentage of people who did not know if the lion-tailed macaques lived in groups (Figure 6.7, $\chi2 = 54.40$, df = 2, $P < 0.001$, N = 237). A greater percentage of 'zoo visitors' answered correctly in comparison to the 'general public' ($\chi2 = 45.65$, df = 1, $P < 0.001$, N = 237).

Figure 6.7 Proportion of zoo visitors and general public who did not know if the lion-tailed macaque lived in groups



ii. Awareness of the need to protect the lion-tailed macaques' habitat

People across cities answered differently to the question whether the lion-tailed macaques were found ('zoo visitors' - 73.81%, 'general public' - 76.67%) with people from Mysore being the least knowledgeable ($\chi2 = 12.24$, df = 2, $P < 0.01$, N = 398). Likewise, when asked what kind of habitat was preferred by the lion-tailed macaque, there was a significant difference across cities with the greatest percentage of people ('zoo visitors' - 54.00%, 'general public' - 42.86%) from Thiruvananthapuram who replied correctly ($\chi2 = 11.02$, df = 2, $P < 0.01$, N = 241). Lastly, 'zoo visitors' and the 'general public' differed in their opinion on whether the lion-tailed macaques habitat should be protected with a greater percentage of the 'general public' (Thiruvananthapuram - 90.67%, Chennai - 100.00%, Mysore - 62.00%) supporting habitat protection ($\chi2 = 8.39$, df = 1, $P < 0.01$, N = 655) in comparison to 'zoo visitors'.

6.5.3.3. Visitors' perception of the zoo

i. Visitors' perceptions of their visit to the zoo

Visitors rated their zoo visit differently across cities with a greater percentage of visitors at AAZP and TZ being appreciative of the lion-tailed macaque exhibit and enjoying their zoo visit. This was in comparison to SCZG where most of the visitors were unsure whether they liked the macaque exhibit (65.87%) and whether they enjoyed the visit (60.32%) (Question about macaque exhibit, $\chi2 = 130.29$, df = 4, $P < 0.001$, N = 413 (number of questionnaires filled in); question about zoo visit, $\chi2 = 245.80$, df = 4, $P < 0.001$, N = 413). To the question on whether the visitor watched the lion-tailed macaques doing anything interesting, a greater percentage of visitors at AAZP and TZ said they did not see anything interesting while 94.43% of the visitors at SCZG said they did not know if they saw the lion-tailed macaque at all ($\chi2 = 239.29$, df = 18, $P < 0.001$, N = 411). Only a small percentage of the visitors documented the actual behaviours they saw the lion-tailed macaque display during their zoo visit. When asked if they fed or teased the animals, 95.70 ± 2.79% of the visitors said they did not because it could harm or disturb them (chi-square test, $\chi2 = 363.94$, df = 3, $P < 0.001$, N = 394). Most of these visitors were from AAZP and TZ.

ii. Visitor awareness of the *ex situ* conservation and educative goals of the zoo

When asked if their visit to the zoo was educational or recreational, the greatest percentage of visitors who thought it was both were from SCZG (65.12%, table 6.1, $\chi2 = 50.0$, df = 6, $P < 0.001$, N = 328). A relatively greater percentage of the 'zoo visitors' at AAZP (20.42%)and TZ (29.20%) stated that the goals of a zoo were to protect endangered species, while 69.05% of SCZG's 'zoo visitors' said they were not aware of what the zoos goals were ($\chi2 = 319.31$, df = 14, $P < 0.001$, N = 405). There was a significant difference across 'zoo visitors' in their answers on whether zoos could save wildlife ($\chi2 = 253.3$, df = 6, $P < 0.001$, N = 411). Of the 'zoo visitors', 65.53 ± 5.21% of the visitors said that zoos could, of which 62.06 ± 17.62% said that zoos could save wildlife through their captive breeding and reintroduction programmes. The greatest percentage of visitors who supported zoos' abilities to protect wildlife was at TZ (82.55%) and this was significantly greater than those from AAZP and SCZG ($\chi2 = 274$, df = 6, $P < 0.001$, N = 411).

6.5.3.4. Public knowledge on lion-tailed macaques habitat

The 'general public' were also asked to list animals that shared the habitat of lion-tailed macaques. There was a significant difference in the way this question was answered across cities with the greatest percentage of public who answered correctly being from Thiruvananthapuram (82.55%, $\chi2 = 89.73$, df = 6, $P < 0.001$, N = 450). Similarly, when asked where tropical rainforests were located in India, the greatest percentage of the 'general public' to answer correctly that they occurred along the Western Ghats in southern India were again from Thiruvananthapuram (61.33%, $\chi2 = 194.6$, df = 6, $P < 0.001$, N = 450).

6.6. DISCUSSION

6.6.1. Study 1: visitor influence study

The presence of visitors at zoo enclosures has been accepted as a factor leading to increased levels of stress in captive wild animals (Hosey & Druck 1987; Chamove *et al* 1988; Mitchell *et al* 1991; Venugopal & Sha 1993; Anderson *et al* 2002; Birke 2002; Mallapur & Chellam 2002; Blaney & Wells 2004; Skyner *et al* 2004). In a study on zoo primates, an increase in visitor numbers was found to increase levels of stereotypic behaviours in a group of mandrills (Chamove *et al* 1988). In the current study, captive lion-tailed macaques exhibited increased levels of abnormal behaviours such as stereotypic pacing, begging, bouncing and self-biting during the presence of visitors compared to time periods when visitors were absent. Hence, although the use of abnormal behaviour as an indicator of poor welfare is complex (Mason 1991), changes in the frequencies of behaviour or an out-of-context exhibition of behaviour, can provide clues to help understand potential welfare problems (Mench & Mason 2000). In the case of captive lion-tailed macaques, the increased levels of abnormal behaviours can perhaps be best explained as a response towards a particular stressor: the visiting public. Captive primate welfare can be assessed through measuring the ability of a nonhuman primate in captivity to cope with its artificial environment. Stressors can lead to the over-taxing of an individual's control systems, in turn reducing its fitness.

Several forms of abnormal behaviours that have been documented in the behavioural repertoire of captive lion-tailed macaques were exhibited only toward visitors (Mallapur, *per obs.*). These individuals were also more agonistic during the presence of visitors 'on-exhibit' and more affiliative 'off-exhibit', when visitors were absent. They yawned more in the presence of visitors, but exhibited greater proportions and frequencies of reproductive behaviours in their absence. Due to the lack of well-established conservation and animal welfare awareness programmes in Indian zoos, the levels of disturbance generated by zoo visitors are typically high. These practices, common in most Indian zoos, include shouting at, teasing, feeding and even physically harming the animals (Venugopal & Sha, 1993). Disturbances such as these have been proved to adversely influence the behaviour of wild animals in captivity (Kratochvil & Schwammer 1997; Birke 2002). Levels of aggression exhibited by captive lion-tailed macaques, in turn, were abnormally high (Mallapur, *pers. obs.*) in comparison to free-ranging individuals (for an ethogram on free-ranging lion-tailed macaques refer to Raghavan 2001) - and much of this non-contact aggression was directed toward visitors. A similar study on captive mangabeys showed that these individuals exhibited high levels of facial threats to zoo visitors (Mitchell *et al* 1991). Other studies have similarly suggested that captive primates are more agonistic and less affiliative during the presence of visitors (Glatson *et al* 1984; Chamove *et al* 1988).

In this study, the use of enclosure space by the captive macaques was also strongly influenced by the presence of visitors with individuals preferentially using the enriched areas of the enclosure to a greater degree when 'off-exhibit'. Such a shift in space-use patterns has also been documented in petting zoos in which captive animals were observed to use enclosure space strategically in order to avoid interactions with zoo visitors (Anderson *et al* 2002).

Apart from visitor influence on captive primate behaviour, several other factors such as observer presence, presence of zoo staff, noise pollution and the presence of vehicular traffic could also affect the behaviour of lion-tailed macaques in captivity. On zoo holidays and off-exhibit, the presence of the zoo staff and the observer could influence the behaviour displayed by the study individuals. However, special care of taken to get the study individuals habituated to the observer before commencing the study.

6.6.2. Study 2: visitor perception study

The results of this questionnaire survey show that the average zoo visitor knew as much about the lion-tailed macaques' biology and behaviour, habitat protection and rainforest conservation as did the 'general public'. Of the six questions that were used to examine the educative influence of the zoos (questions 5 to 9 in the visitor perception questionnaire, refer Appendix 6.2; questions 2 to 7 in the public perception questionnaire, refer Appendix 6.3) only two questions were answered correctly by a greater percentage of the zoo visitors. There was no significant difference between the answers of the zoo visitors and the general public with regard to three of the remaining four questions. Hence, there were no marked differences in the answers given to these questions by the zoo visitors and the general public across the three zoos, suggesting that a visit to AAZP, SCZG or TZ was not educational to its 'zoo visitors'.

6.6.2.1. Levels of awareness in the three study sites

Interestingly however, the people at Thiruvananthapuram - 'zoo visitors' and the 'general public' alike - were most knowledgeable about the biology and behaviour of the lion-tailed macaque while the people from Mysore were the least so. There are two probable explanations for this difference. Of the three cities, Thiruvananthapuram is most closely located to the habitat of this macaque. Since a large percentage of the 'zoo visitors' comes from neighbouring cities, towns and villages, the chances of 'zoo visitors' and the 'general public' in Thiruvananthapuram having seen a lion-tailed macaque in its natural habitat is considerably higher. The second explanation could be that Thiruvananthapuram is the state capital of Kerala, the state with the highest literacy in India (91%, <http:// members.tripod.com/ ~INDIA_RESOURCE/ census. html>, 17/5/04), and people here may, therefore, generally be more knowledgeable.

6.5.2.2. The educative influence of the three study zoos

Several of the questions in the survey were included to study visitor perception of zoos in general. Interestingly, when asked about the goals of the zoo and whether zoos could indeed help protect wildlife, an encouraging response was received with nearly two thirds of the visitors sampled suggesting that the goals of a zoo were predominantly that of conservation, education and entertainment, and that zoos helped wildlife by protecting endangered species and by educating the public about the environment. A similar type of study was carried out on the attitudes, knowledge, and education of 5000 residents living on the urban-wildland divide across five cities on the borders of the Nature Reserve of Orange County, California (Shalene & Crooks 2002). The study compared the attitudes of residents to whom the Nature Reserve's brochure had been issued with those to whom it had not. Interestingly, the results revealed very few differences in their responses. The researchers however suggest that education efforts need to be tailored to suit the knowledge and attitudes of the target audience (Shalene & Crooks 2002). Another study on conservation education in zoos also emphasises the importance of being informed of the topics spontaneously discussed by 'zoo visitors' especially since one of the missions of zoos is that of conservation education (Tunnicliffe 2002).

6.5.2.3. Visitor perceptions of the zoo goals

Several visitors suggested that their visit to the zoo was enjoyable and was a learning experience since the zoo is the only place they could see several species of animals, especially exotics, and even learn about them. Watching live animals in zoos can be an awe-inspiring experience, especially for young children and school students. This should perhaps be used strategically by zoos to convey a powerful conservation message, which, in turn, can bring about positive changes in public attitudes and behaviour (<http://www.zooreach.org/ZooEdu/ZooEdBook/ZooEdBook.htm>, 1/3/2004). Of the visitors who saw the lion-tailed macaque at the zoo, most liked the exhibit because it was large, spacious, clean and very green. Many suggested that the lion-tailed macaques looked comfortable in their exhibit. Approximately 60 million people visit zoos in India annually (B C Choudhury, *pers. comm.*). Indians, in general, like zoos and their enthusiasm to see animals bring them in multitudes to their local zoos every year. Other visitor studies conducted by researchers, however, also indicate that the public worldwide usually does not visit zoos to learn about wildlife but to entertain themselves (http://www.zooreach.org/ZooEdu/ZooEdBook/ZooEdBook. htm, 1/3/2004). These studies also suggest nevertheless that when information is presented in a creative fashion, the very same visitors enjoy their educational experience.

6.5.2.4. Zoo education programmes at the three study zoos

There are approximately 300 zoos in India, of which only four of them conduct conservation awareness programmes or even have education staff. Of these zoos, AAZP, SCZG and TZ conduct awareness programmes for students of different age groups and for teachers. While the AAZP and TZ have their own education officers who conduct these programmes, SCZG has a team of volunteers who help the zoo manage its educational activities. The educational programmes conducted at AAZP involve a brief lecture about wildlife conservation, a slideshow or a documentary and finally a zoo tour. These programmes are conducted fairly often - at least twice a week. At SCZG, the zoo volunteers help run a training programme, which involves lectures and hands-on experience on working with the zoo animals every Sunday for a period of six months. This programme is held for a group of 60 school children. In TZ conservation awareness programmes, competitions and games, slideshows and documentaries are usually held during a particularly-designated national wildlife week. The education activities of the three zoos are also displayed on their respective websites; these target different groups of people and also cover varied topics in wildlife including rainforest conservation. However, none of these programmes are designed for the average zoo visitor. While AAZP does offer the visitor a zoo guide, which contains detailed information of all the species housed in the zoo, the guide is, unfortunately, fairly expensive and few, therefore, ever get sold. The zoos at SCZG and TZ do not provide their visitors with any information about the zoo animals except for the labels positioned at each exhibit.

6.5.2.5. Strategies to improve education programmes at the study zoos

In order to improve the educational influence of these three zoos on their visitors, it would be imperative for the zoos to first and foremost conduct some basic and applied research in visitor studies. These studies would help them understand and gauge the problem at hand and help them devise new strategies be it for education, animal welfare or wildlife conservation. For example, this questionnaire survey clearly suggests that the zoos are not educative to the average visitor. Visitors who are unaware or disinterested in the animals on exhibit could prove harmful to these animals in the wild. Research has shown that visitors can also disturb animals in zoos (see previous section). The extent of disturbance by zoo visitors has been monitored in several zoos and methods to reduce it have been devised (Kratochvil & Schwammer 1997; Birke 2002). Visitors sometimes announce their displeasure at something else by disturbing the zoo animals (*pers. obs.*). Since several zoos have conducted periodic questionnaire surveys to study visitor perceptions on various issues such as their interest in a new exhibit (Wilson *et al* 2003; Blaney & Wells 2004), a particular taxa (Margulis *et al* 2003), or a new husbandry regime (Ings *et al* 1997; McPhee *et al* 1998; Wood 1998), results from such questionnaire surveys could be analysed in an effort to improve visitor interest in particular exhibits or overall, in the zoo itself.

6.7. CONCLUSIONS

6.7.1. Study 1: visitor influence study

In this chapter, the adverse influence of the presence of zoo visitors on the behaviour and welfare of captive lion-tailed macaques in Indian zoos has been documented. Poor welfare due to stress could influence an individual's ability to breed. For an endangered, endemic species such as the lion-tailed macaque, it would be imperative to monitor stressors such as the presence of zoo visitors closely in order to establish a long-term breeding programme. In order to reduce stress caused by zoo visitors, groups or individuals can be shifted to 'off-exhibit' breeding facilities. If such a facility does not exist in a particular zoo, 'on-exhibit' enclosures could be renovated to incorporate increased flight distances by providing a complex environment; such measures can potentially consist of an access to the vertical dimension (through ropes, vines, trees and logs), hide-outs generated by including visitor barriers, and visitor barricades between the visitors and the primate exhibit.

6.7.2. Study 2: visitor perception study

The results of this questionnaire survey suggest that 'zoo visitors' do not necessarily know more about the biology and behaviour of the lion-tailed macaque, protection of its habitat and rainforest conservation than does the 'general public'. A visit to AAZP, SCZG or TZ - zoos in three southern Indian cities where this survey was conducted - is thus not educational to its 'zoo visitors'. However, the people at Thiruvananthapuram, in general, were more knowledgeable about the lion-tailed macaque as compared to the people in the other two cities. This study suggests, therefore, that there is an absolute need for education programmes for visitors in these zoos, and perhaps, by extension, to most Indian zoos. Information booklets describing the zoo animals also need to be handed out or put up as information placards in these zoos.

CHAPTER VII *Reproductive Behaviour*

CONTENTS

Identifying the factors that influence breeding in captive lion-tailed macaques (*Macaca silenus*) housed in Indian zoos.

7.1. ABSTRACT

A lion-tailed macaque's age and early rearing history were found to be related to its breeding success. Proven breeders were significantly younger in age when compared to non-breeding and singly-housed individuals, especially in the case of the males. Non-breeding individuals, especially the males, were more likely to be confiscated from private owners when compared with the proven breeders who were more likely to be born in zoos. Proven breeders in comparison to non-breeders exhibited lower levels of agonistic behaviours such as 'bared-teeth face' towards humans. Proven breeders also exhibited higher levels of reproductive behaviours and social interactions than non-breeders. In the case of grooming, males and females with proven breeding history exhibited higher percentages of autogrooming than non-breeding females and males respectively. Differences in behaviour between proven breeders and non-breeders may be due to the fact that most of the non-breeders were owned as pets by private owners and were later confiscated. This could have had an influence on the development of behaviour during the early stages of their lives. Individuals who form part of a breeding programme that intends to either maintain self-sustaining populations in captivity or to release them in their natural habitat need to be chosen carefully on the basis of age, presence of humans and rearing history. It is recommended that individuals that have been in close contact with humans and not of their own kind when they were young should not be part of a breeding programme.

Key words: animal welfare, reproductive behaviour, rearing history, lion-tailed macaque, zoo, India

7.2. INTRODUCTION

Zoos and conservation centres complement *in situ* conservation efforts to save species that are on the verge of extinction by breeding endangered species in order to reintroduce them into their natural habitat (IUDZG/CBSG (IUCN/SSC) 1993). The lion-tailed macaque is one such endangered species (Nameer *et al* 2001) and is endemic to the tropical evergreen rainforests of the Western Ghats of south India (Green & Minkowski 1977; Lacy *et al* 1996; Singh *et al* 1997). When it was decided that the population numbers of the lion-tailed macaque were dwindling in the wild and that the species required sanctuary in captivity (Foose & Conway 1985), breeding programmes were set up internationally. In North America and Europe the genetics and demography of the captive populations were regulated through a collaborated effort by institutions and individuals, leading to a successful breeding programme by the 1990s (Kaumanns *et al* 2001; Lindburg 2001).

For the efficient management of breeding programmes of captive populations of primates, it is important to ensure that the populations are healthy, to safeguard their long-term viability. Proper diets and veterinary care are as critical to a captive colony of primates as is demographic and genetic management (Wiese & Hutchins 1995). One of the goals of organised conservation breeding programmes is to maintain a genetically diverse and demographically stable, self-sustaining population of living organisms. For example, to address the problem of the reducing numbers of free ranging wild golden lion tamarins (*Leontopithecus rosalia*), the National Zoological Park, USA and Smithsonian Institution, USA initiated a long-term investigation into the reproduction, social behaviour and husbandry of this species in captivity (Kleiman *et al* 1986; Kleiman & Mallinson 1996; Stoinski *et al* 1997). Studies showed that golden lion tamarins were being inappropriately fed and housed. Changes in the diet and social housing conditions resulted in a tremendous increase in golden lion tamarins in captivity by the 1970s and 1980s (Kleiman *et al* 1991).

Another case study shows that the lion-tailed macaque population in U.S zoos doubled in size in a decade. This occurred after the importation of wild lion-tailed macaques from India was stopped voluntarily by American zoos, due to growing concern over their dwindling numbers in the wild (Lindburg *et al* 1997). This dramatic increase in the captive numbers arose from the intensified effort and improved management techniques in zoos (Lindburg & Gledhill 1992). Lindburg *et al* (1997) explain how the study also considered welfare of this highly social species by monitoring social interdependency and stability, rearing environments and kinship relationships. Individuals were always housed in species-specific social groupings and were only isolated for veterinary care. To promote social stability, some males were housed within exhibit groups with the females and their offspring. These males were vasectomised to avoid unwanted pregnancies, which also allowed the full expression of sexual behaviour to occur. Some institutions housed the surplus individuals for educational purposes, while others housed all male troops.

By conducting basic and applied research and through long-term monitoring of breeding groups, zoos in North America and Europe have proved that they managed to breed, maintain and develop breeding programmes for the lion-tailed macaque. In Indian zoos however, the breeding programme for this species proved unsuccessful, even though the lion-tailed macaques are distributed across 18 zoos in India (Mallapur in press). The main reason for the failure of the breeding programme is probably the low number of breeding females in the population (*pers. obs.*; also refer to Mallapur in press). Presently, over the last two years, only two females, both housed at Arignar Anna Zoological Park, Chennai are breeding, while the populations in other zoos slowly reduce in size due to the mortality of the older individuals (Mallapur in press). The current situation of lion-tailed macaques in Indian zoos suggests that further research needs to be conducted in order to identify the factors that may have a detrimental influence on breeding and the performance of reproductive behaviour in this species.

7.3. AIM

The aim of this chapter was to identify the factors that influence breeding and the performance of reproductive behaviour in lion-tailed macaques housed in Indian zoos. The differences in reproductive behaviour between non-breeding lion-tailed macaques and proven breeders housed in Indian zoos were also recorded to help identify factors influencing their current ability to breed.

7.4. METHODOLOGY

7.4.1. General methods

This behavioural study was conducted on 36 captive lion-tailed macaques from 10 groups (20 non-breeding individuals (seven males & thirteen females) housed in seven groups, six breeding individuals (three males & three females) housed in two groups and 10 singly-housed individuals (nine males & one female)) housed in 12 Indian zoos (Table 7.1). Of the six breeding individuals, the breeding male and female from Bhilai (MBZ) were housed separately adjacently in such a way that they could see and smell each other. In this zoo, the male is introduced to the female when she is in oestrus. Individuals and groups were categorised according to their breeding history, from the information obtained from studbook records maintained by the zoo staff at each zoo. Individuals were categorised as non-breeders either if they had not bred over the last five years or if they had never bred. Proven breeders were individuals who had bred at least once over the past five years. The singly-housed individuals were housed in adjacent enclosures so that they could see, touch and smell one another. Reproductive behaviours displayed by breeding, non-breeding and singly-housed individuals were compared to record differences on a continuum from singly-housed to breeding individuals. The feeding time and the time at which the animal keepers cleaned the enclosures varied across zoos (see feeding and keeper cleaning schedules in Table 2.2 and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*). The diet charts also varied considerably across zoos (see diet charts Table 2.3 and Section 2.1.2 *Animal Husbandry* in Chapter II *General Methods*). Observations were conducted between June 2002 and October 2003. The study was conducted at the following zoos:

1. Arignar Anna Zoological Park (AAZP), Chennai, Tamil Nadu state
2. Guindy Children's Park (GCP), Chennai, Tamil Nadu state
3. Jaipur Zoo (JZ), Jaipur, Rajasthan state

4. Maitri Baagh Zoo (MBZ), Bhilai, Chhattisgarh state
5. Mini Zoo (MZK), Kodanad, Kerala state
6. Mini Zoo (MZT), Thattekkad, Kerala state
7. Nandankanan Biological Park (NBP), Bhubaneshwar, Orissa state
8. National Zoological Park (NZP), New Delhi, Delhi state
9. Patna Zoo (PZ), Patna, Bihar state
10. Shri Chamarajendra Zoological Gardens (SCZG), Mysore, Karnataka state
11. State Museum and Zoo (SMZ), Thrissur, Kerala state
12. Thiruvananthapuram Zoo (TZ), Thiruvananthapuram, Kerala state

Table 7.1 Lion-tailed macaques studied in Indian zoos

Zoo[1]	Number of lion-tailed macaques studied		Breeding History
	Group composition[2]	Total group size[3]	
AAZP	1:1:2[4]	2 (1:1:0)	Proven breeder [B[4]]
GCP	1:1:0[5]	2 (1:1:0)	Non-breeder [NB[5]]
JZ	1:1:1	2 (1:1:0)	Proven breeder
MBZ	**1:0:0[6], 1:0:0**, 0:1:1	3 (2:1:0)	Singly-housed individuals [SI[6]], Proven breeder
MZK	**1:0:0, 1:0:0**, 1:1:0	4 (3:1:0)	Singly-housed individuals, Non-breeder
MZT	**1:0:0, 0:1:0**	2 (1:1:0)	Singly-housed individuals
NBP	1:1:0	2 (1:1:0)	Non-breeder
NZP	1:1:0	2 (1:1:0)	Non-breeder
PZ	1:2:0	3 (1:2:0)	Non-breeder
SCZG	1:3:0	4 (1:3:0)	Non-breeder
SMZ	**1:0:0, 1:0:0, 1:0:0**	3 (3:0:0)	Singly-housed individuals
TZ	**1:0:0, 1:0:0**, 1:4:0	7 (3:4:0)	Singly-housed individuals, Non-breeder

[1] For the full names of the zoos, see above
[2] Refers to the number of sexually mature males: sexually mature females: young (infants and juveniles) in each group.
[3] The total number of animals observed is given with the total number of males and females observed. Young were not observed during this study.
[4] Individuals/ groups that have bred over the past five years.
[5] Individuals/groups that have not bred over the past five years and those that have never bred
[6] Individuals that are housed singly. These individuals are marked in bold in the group composition column

7.4.2. Behavioural sampling

During the study, a combination of focal animal sampling and instantaneous scanning was used to quantify the behaviour displayed by the captive macaques (see Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). Each individual with proven breeding history was observed for a period of a mean (± SE) of 4.83 ± 0.76 h (N = 6), non-breeding individuals for 6.02 ± 1.35 h (N = 20) and singly-housed individuals for 5.33 ± 0.59 h (N = 10). A total of 202.6 hours was spent observing these animals (N = 36) across the 12 zoos. All individuals that were exhibited to the public were studied for a period of nine hours during the day between 0830 h, when the zoo opened in the morning and 1730 h, when it closed for the day. Each behavioural sampling session was initiated with an instantaneous scan, and was followed by a focal animal sample of one of the individuals in the group for a duration of 15 min (see Section 2.2 *Behavioural Methodology* in Chapter II *General Methods*). The study period could range from seven to 10 days (for one group) in some places. The time spent at each zoo usually depended on the number of lion-tailed macaques housed in that group. Three observation days were spent on each of the singly-housed individuals.

7.4.3. Space use

The use of enclosure space by captive lion-tailed macaques was recorded during the instantaneous scans conducted to record the behavioural states (see Section 2.3 *Space Use* in Chapter II *General Methods*).

7.4.4. Data analyses

Data for non-breeding females housed in groups consisting of more than one female were pooled at the end of the observation period to obtain a group average for all the females in the group (see Section 2.4 *Data Analyses* in Chapter II *General Methods*). This was done to maintain social independence during data analyses. Hence, even though the behaviour of 13 non-breeding females was recorded, the data were pooled group-wise to obtain group averages for the seven non-breeding groups. However, since all non-breeding groups included one male and all the breeding groups consisted of one male and one female each, data of individuals were used for analyses. Each individual's current breeding status was ranked for analysis (Table 7.2). These ranks were then used to analyse the differences between breeding and non-breeding individuals. Ranks were given separately for males and females. The Wilcoxon-Mann-Whitney Test was used to determine the differences levels of behaviour exhibited and percentage enclosure space used between breeding and non-breeding individuals (Siegel & Castellan 1988; for more information on tests, refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). The Kruskal-Wallis one-way analysis of variance by ranks test was used to determine whether factors such as rearing history have a significant influence on the lion-tailed macaques' current ability to breed (Siegel & Castellan 1988; for more information on tests, refer to Section 2.4 *Data Analyses* in Chapter II *General Methods*). For this purpose, rearing history was quantitatively ranked on an arbitrary scale, as shown in Table 2.5 in Chapter II, in order to conduct statistical analyses. The Wilcoxon signed ranks test was used to determine the difference between visitor presence and absence on reproductive behaviours exhibited (Siegel & Castellan 1988). All sample sizes mentioned in the text refer to lion-tailed macaque individuals and not groups. All P values that have been reported are two-tailed. SPSS (Version 7.5) was used to conduct the statistical analyses.

Table 7.2. Ranks given to non-breeders, proven breeders and singly-housed individuals for analysing differences in social and reproductive behaviours exhibited

Rank	Males	Females	Group
Singly-housed individuals	0	0	0
Non-breeders	1	1	1
Proven breeders	2	2	2

7.5. RESULTS

There were several distinct differences between the behaviours exhibited by breeding and non-breeding captive lion-tailed macaque groups housed in Indian zoos.

7.5.1. Reproductive behaviours

'Presenting without lipsmacking' (see Appendix 4.1 for definitions of behaviours) which resulted in inspection towards other lion-tailed macaques was exhibited at significantly greater frequencies per hour by females with proven breeding history

(B) in comparison to non-breeding females (NB, Figure 7.1, U = 1.000, N = 7 (NB females) and 3 (B females), $P < 0.05$). B females also exhibited 'presenting with lipsmacking' which resulted in inspection towards lion-tailed macaques more frequently than NB females (Figure 7.1. U = 1.000, N = 7 and 3, $P < 0.05$).

Figure 7.1. Differences in reproductive behaviour between breeding and non-breeding female captive lion-tailed macaques

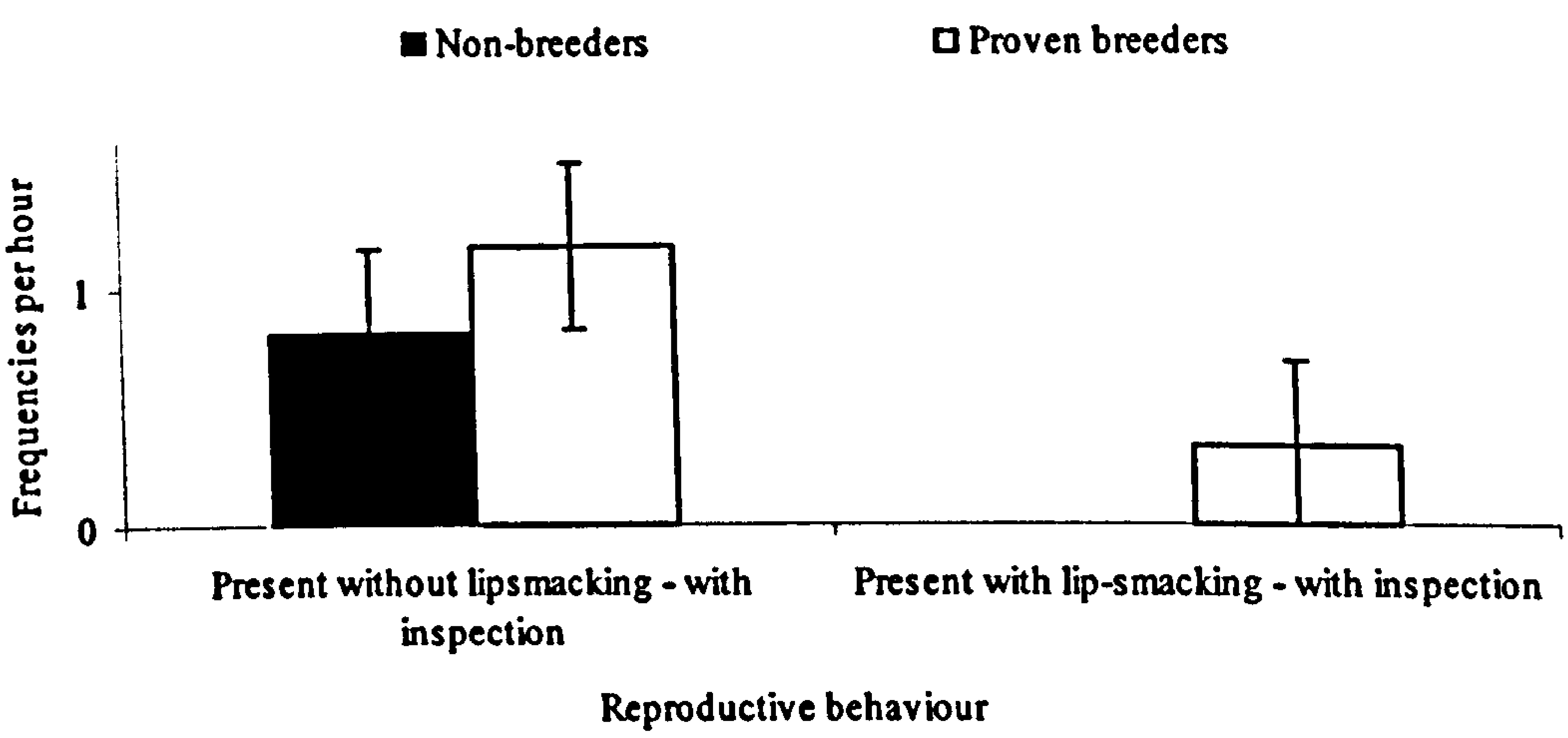
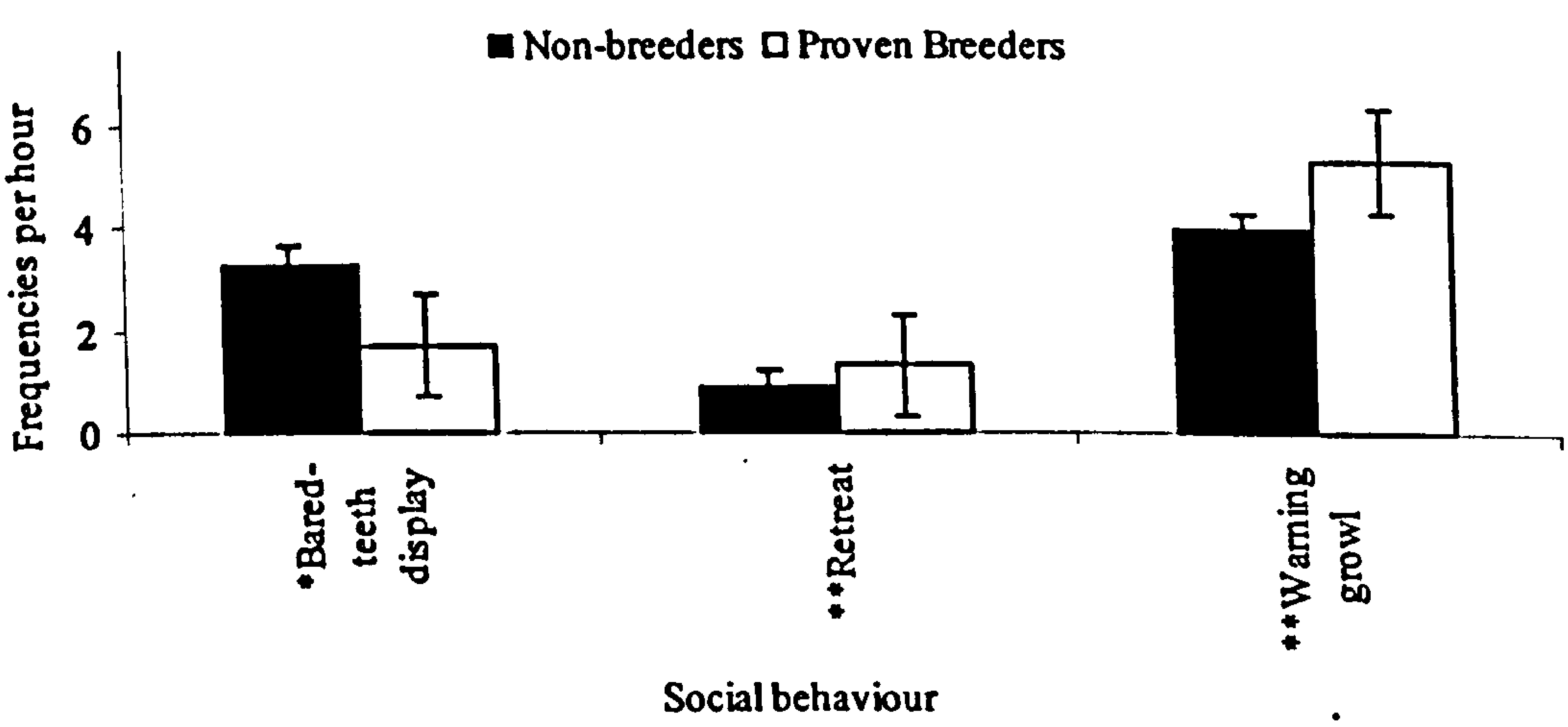


Figure 7.2. Differences in social interactions between breeding and non-breeding groups of captive lion-tailed macaques



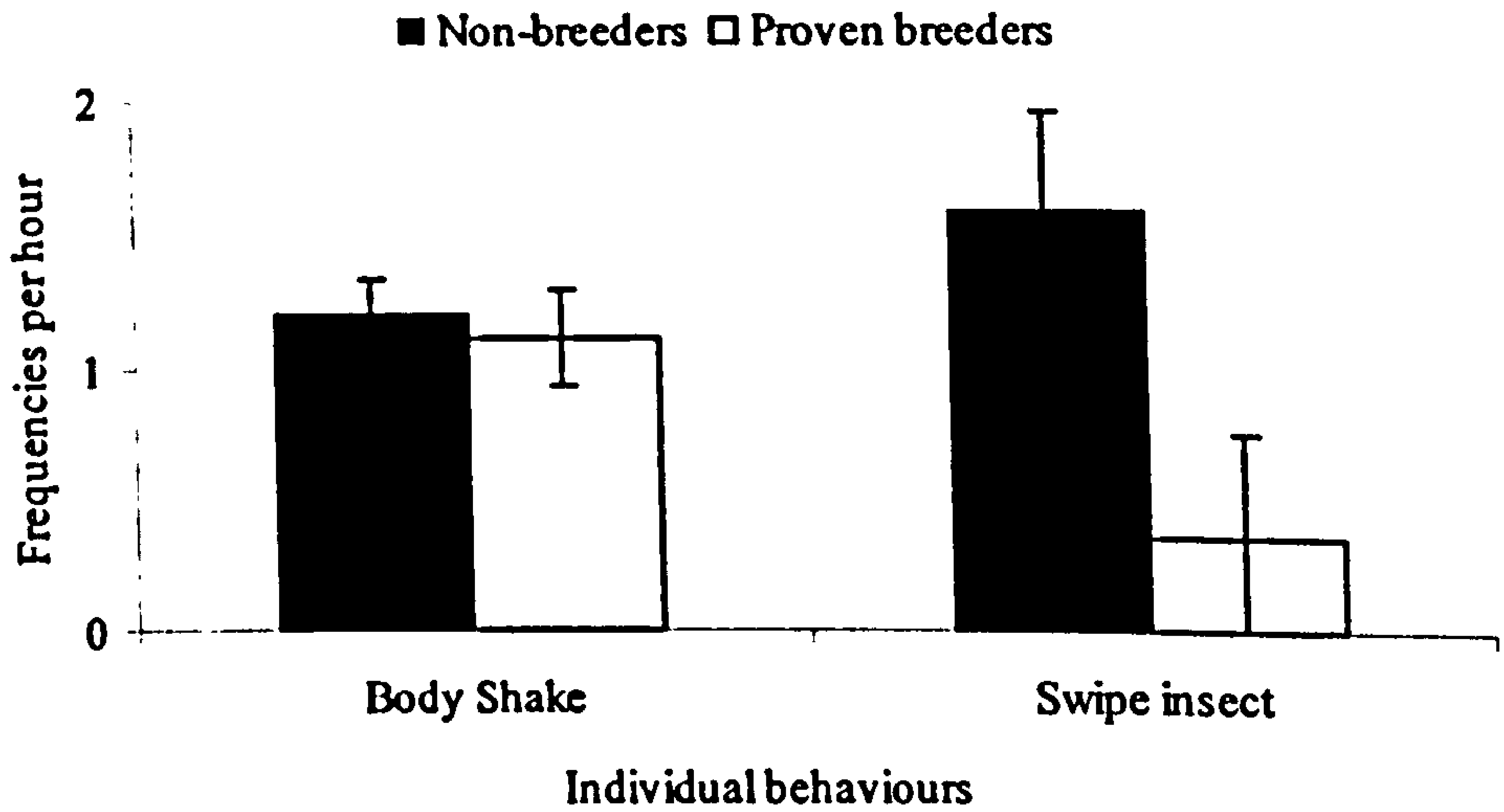
* exhibited towards humans only, **exhibited towards other lion-tailed macaques

7.5.2. Other social interactions

NB individuals exhibited 'bared-teeth display' more frequently towards humans (visitors and zoo staff) than did the B individuals, especially in the case of the males

(For overall comparison B vs. NB, Figure 7.2, U = 8.000, N = 7 (total NB individuals) and 3 (total B individuals), $P < 0.05$; NB males vs. B males, U = 0.000, N = 7 (NB males) and 3 (B males), $P < 0.05$). B individuals 'approached without receiving a retreat response' from other lion-tailed macaques, more frequently than did NB individuals (Figure 7.2, U = 31.500, N = 7 and 3, $P < 0.05$). Similarly, B individuals also exhibited 'warning growl' more frequently than did NB animals (Figure 7.2, U = 31.500, N = 7 and 3, $P < 0.05$).

Figure 7.3. Differences in individual behaviours between breeding and non-breeding captive female lion-tailed macaques



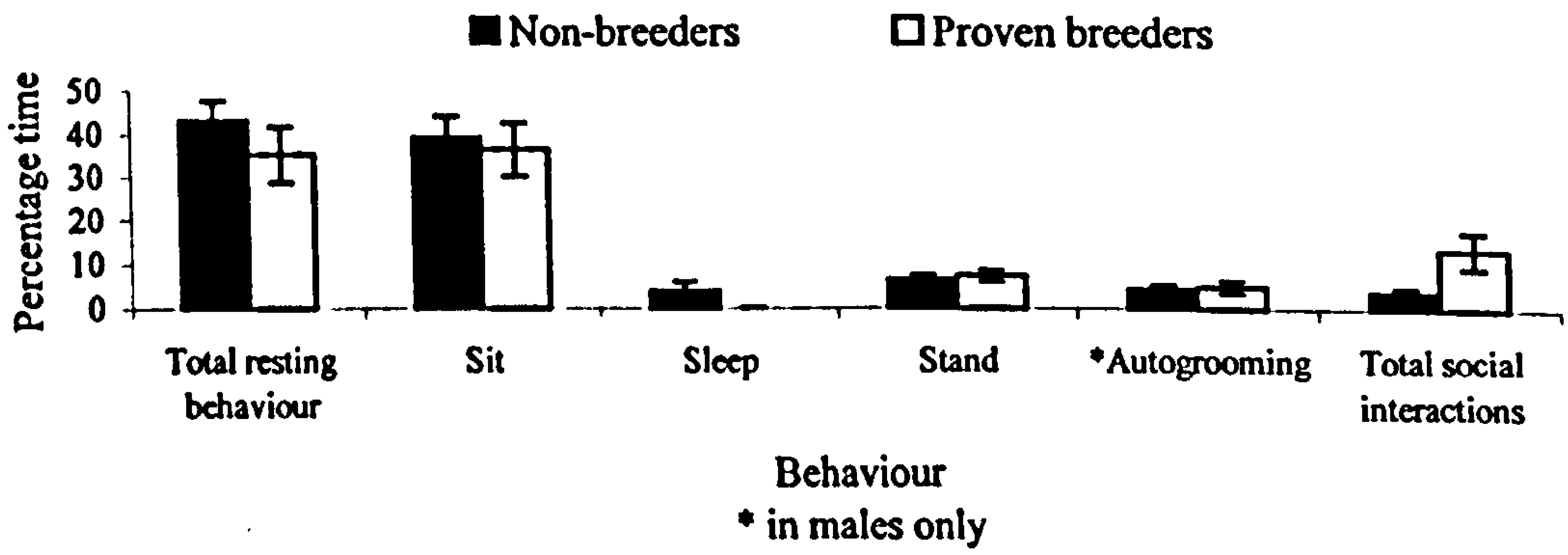
7.5.3. Other individual behaviours

'Body-shaking' was exhibited to lower frequencies by breeding females in comparison to NB females (Figure 7.3, U = 8.000, N = 7 and 3, $P < 0.05$). Non-breeding individuals exhibited 'swiping for insects' more frequently than the proven breeders, especially in the females (Overall comparison B vs. NB; see Figure 7.3, U = 11.000, N = 7 (total NB individuals) and 3 (total B individuals), $P < 0.005$; comparison for females only B vs. NB; U = 6.000, N = 7 (NB females) and 3 (B females), $P < 0.05$).

7.5.4. Behavioural states

Non-breeding lion-tailed macaques exhibited greater percentages of 'sleep', 'sit' and 'total resting behaviour' than the B individuals (Figure 7.4, sleep, $U = 30.000$, $N = 7$ (total NB individuals) and 3 (total B individuals), $P < 0.05$; sit, $U = 31.500$, $P < 0.05$; total resting behaviour, $U = 30.000$, $P < 0.05$). B individuals exhibited 'stand' and 'total social interactions' at a greater percentage than did NB animals (Figure 7.4, Stand, $U = 30.000$, $P < 0.05$; Total social interactions, $U = 31.500$, $P < 0.05$). 'Auto-grooming' was exhibited to significantly more by breeding males in comparison to NB males (Figure 7.4, $U = 28.000$, $N = 7$ and 3, $P < 0.05$) while 'standing' was exhibited to greater percentages by B females when compared to NB females ($U = 4.000$, $N = 13$ and 3, $P < 0.05$).

Figure 7.4. Differences in percentages (mean +/- S.E) of behaviour exhibited between breeding and non-breeding groups of captive lion-tailed macaques



7.5.5. Use of enclosure space by proven breeders and non-breeding lion-tailed macaques

There were no significant differences in the use of enclosure space between non-breeding individuals and proven breeders.

7.5.6. Factors influencing the captive lion-tailed macaques' ability to breed

When age and rearing history was compared across singly-housed lion-tailed macaques, proven breeders and non-breeding individuals a significant difference was found. Rearing history ranks negatively correlated with ranks given to each individual on their ability to breed. This suggested that non-breeding individuals, especially the males, were more likely to be those that had been confiscated in comparison to the proven breeders who were most likely to be zoo-born or captive-reared (Overall comparison: $\rho = -0.49$, $N = 21$ (total lion-tailed macaque individuals), $P < 0.05$; Males only, $\rho = -0.57$, $N = 18$ (males), $P < 0.05$). B individuals were significantly younger than the NB individuals and those that were singly-housed ($\chi^2 = 7.09$, $df = 2$, $N = 10, 7, 4$, $P < 0.05$).

The frequency of reproductive behaviours exhibited was significantly lower during days with visitors present than on zoo holidays ($Z = -2.604$, $P < 0.05$, $N = 26$). On days with visitors present, reproductive behaviours was the least frequently exhibited category of behaviours, whereas on zoo holidays the frequencies of reproductive behaviours were greater than abnormal behaviours (Zoo holidays, $\chi^2 = 30.8$, $df = 3$, $P < 0.005$, $N = 26$ (total breeding and non-breeding individuals); visitors present, $\chi^2 = 39.9$, $P < 0.005$).

7.6. DISCUSSION

In this study, despite the low numbers of breeding macaques, it was possible to find a marked difference in the behavioural repertoires exhibited by non-breeding lion-tailed macaques and those with proven breeding history. Individuals who had bred in the past tended to be younger and they exhibited lower amounts or no abnormal behaviour. Non-breeding individuals were most likely to have been confiscated from private owners, while proven breeders were predominantly born in zoos. Several environmental factors are known to influence the reproductive behaviour of mammals in captivity, some of these factors being enclosure space and complexity (Hediger 1964), presence of conspecifics at an early age (Anderson & Chamove, 1980, 1985;

Chamove *et al* 1984; Mootnick & Baker 1994; Estep & Dewsbury 1996; Mallapur & Choudhury 2003; Mallapur in press), diet and nutrition (Oftedal & Allen 1996) and even the presence of humans (Carlstead 1996).

7.6.1. Difference between breeding and non-breeding individuals

In the case of the captive lion-tailed macaques in this study, females that had bred in the past exhibited social interactions and reproductive behaviours such as presenting to the males in their group to a much greater level, than non-breeding females did to the males in their groups. The non-breeders were also observed to spent greater proportions of time resting compared to the proven breeders. The current inability of groups in which either the male or female/s or both have been confiscated from private owners to breed suggests that being reared in isolation and in the presence of humans could have deprived them of an appropriate social environment. This early social deprivation could have lead to the development of abnormal behaviours such as self-injurious behaviours and stereotypies, which may be due to the absence of species-specific environmental stimuli essential for the development of a natural behavioural repertoire. In lion-tailed macaques, especially in the case of males, field biologists have observed that reproductive behaviours such as courtship and copulatory behaviour develop at an early age of 1 to 3 years (Sharma *pers. comm.*, 07/03/03).

7.6.2. Influence of rearing (early) experience on current ability to breed

Scientists have suggested that early social isolation from conspecifics (for example Anderson & Chamove, 1980, 1985; Chamove *et al* 1984; Mootnick & Baker 1994; Estep & Dewsbury 1996; Mallapur & Choudhury 2003; Mallapur in press) or even specifically, absence of mother-rearing (Hediger 1964; Carlstead 1996) could result in the absence of the specific stimulation required for the normal development of social regulation and complex goal-directed behaviours such as maternal and reproductive behaviours. In a study on non-human primates housed in Indian zoos, macaques (for example pig-tailed macaques, *Macaca nemestrina* and stump-tailed macaques, *Macaca arctoides*) that were confiscated from private owners (reared in isolation and in human contact) exhibited abnormal behaviours and did not reciprocate courtship signals or behavioural sequences (Mallapur & Choudhury 2003). Similar observations were recorded with the captive lion-tailed macaques in the present study, especially in the case of the males in the non-breeding groups. In several cases, males were observed to mount females on their side or head, which clearly suggested that they did not know how to copulate.

7.6.3. Influence of visitor presence on current ability to breed

The presence of the zoo visiting public could also influence the reproductive behaviour of the breeding animals. In this study, captive lion-tailed macaques in both the breeding and non-breeding groups exhibited reduced reproductive behaviour during the presence of visitors. A similar observation was recorded during a study conducted on captive cotton-top tamarins housed in pairs. The study showed that pairs on-exhibit displayed lower levels of mounting and other forms of social behaviour in comparison to the animals off-exhibit (Glatston *et al* 1984). Human contact during the early stage of life could also pose a problem by leading to socialisation with humans, which could lead to the development of several behavioural patterns not found in free-ranging or mother-reared infants (Hediger 1964; Carlstead 1996; Mallapur & Choudhury 2003; Mallapur in press). In this study, captive lion-tailed macaques were observed to frequently direct sexual behaviours towards humans, with NB displaying aggressive behaviour such as bared-teeth face towards humans to greater frequencies than proven breeders. Although both males and females exhibited these behaviours, males continued to do so even when one or more females in his group were in oestrus. Similar behaviours were recorded by Mootnick and Baker (1994) in their study on eight species of gibbons (*Hylobates* spp.), in which several individuals were observed to direct sexual behaviours towards humans, specifically staff known to them. In another study on domestic cats (*Felis domesticus*), hand-reared animals were observed to frequently show sexual preferences for humans (Mellen 1992).

7.7. CONCLUSIONS

It is clear from this study that age, presence of humans and rearing history can influence a lion-tailed macaque's ability to breed in captivity.

7.7.1. Age

Non-breeding individuals were significantly older than individuals with proven breeding history. This probably suggests that an animals' ability to breed decreases with age.

7.7.2. Presence of humans

Presence of humans at any stage in the lives of these macaques was found to adversely influence their breeding. It would be advisable to house breeding groups 'off-exhibit' to reduce any possible stress caused by visitors. Individuals that were either hand-reared or were in close contact with humans during the early stages in life were observed to exhibit sexual behaviours toward humans and did not reciprocate courtship signals and behaviours directed toward them by conspecifics in the group (even when females were in oestrus). These individuals tend not to breed and may not in the future. It would hence be preferable to form groups of animals that had early social experience with conspecifics. Social and sexual behaviours directed toward humans can also be used as an indicator to identify individuals with no contact with conspecifics during the early stage in their lives.

7.7.3. Early (rearing) experience

Individuals isolated at a young age exhibited self-injurious behaviours, stereotypies and even abnormal sexual behaviours. These individuals, especially the males, tend not to breed and may not breed in the future, and hence should not be included in breeding programmes. The presence of self-injurious behaviours and abnormal sexual behaviours in the behavioural repertoire of these individuals could be used as an indicator to identify animals that were reared in isolation. These abnormal behaviours can also indicate the absence of normal courtship and copulatory behaviours in their behavioural repertoire since these behaviours develop in the presence of conspecifics during the early stage of life.

CHAPTER VIII *Welfare Indicators*

CONTENTS

Choosing Indicators to Assess the Welfare of Captive Lion-tailed Macaques (*Macaca silenus*)

8.1. ABSTRACT

Twelve variables were standardised in order to be used as indicators for assessing the welfare of captive lion-tailed macaques housed in zoos. They were broadly classified into body condition, behaviour and health, and demographic parameters. Since the lion-tailed macaques were a part of a breeding programme, only some 'non-invasive' and 'hands-off' measurements were recorded and these have been used this study. Of the 12, 10 variables accounted for the greatest proportion of variability between the 51 lion-tailed macaques observed across 13 Indian zoos. The first group of variables accounted for the largest proportion of the total variance. It consisted of movement, body mass, fur condition and age and was called the 'physical-condition factor'. The second group of variables consisted of rearing history, current ability to breed and durations and frequencies of behaviour and was called that 'developmental and reproductive success factor'. These two factors were found to be most suitable to assess the welfare of captive lion-tailed macaques.

Key words: welfare indicators, welfare assessment, abnormal behaviour, animal welfare, lion-tailed macaque

8.2. INTRODUCTION

In order to gain a better understanding of a wild animal's ability to cope with its captive environment and to provide it with the required assistance to do so, it is imperative for animal carers and scientists to be able to precisely assess the welfare of each individual. Some species are more prone to the effects of captivity than others (for example Anderson & Chamove 1980; Anderson & Chamove 1985; Shepherdson *et al* 2004), and this may result in the performance of abnormal behaviours (Erwin & Deni 1979; Mason 1991; Mench & Mason 2000; for example Fritz *et al* 1992; Marriner & Drickamer 1994; Mootnick & Baker 1994; Worlein & Sackett 1997; Lukas 1999; Mallapur & Choudhury 2003; Mallapur in press) or even in reduced reproductive rates (Carlstead 1996; Estep & Dewsbury 1996).

There are many methods of assessing welfare, including behaviour (Mench & Mason 2000; for example Clubb & Mason 2001; Shepherdson *et al* 2004), body condition and health (Hughes & Curtis 2000; for example Webster *et al* 2004), parameters of immune function, endocrine parameters and cardiovascular output (Terlouw *et al* 2000; Shepherdson *et al* 2004), reproductive parameters and longevity (Carlstead 1996; for example Clubb & Mason 2001; Webster *et al* 2004), and preference testing (Fraser & Matthews 2000; for example Hosey *et al* 1999).

The parameters which are most commonly used to assess the welfare of captive primates maintained in zoos are behaviour (Cook & Hosey 1995; Hebert & Bard 2000; Waitt & Buchanan-Smith 2001; Birke 2002; Little & Sommer 2002; Mallapur & Choudhury 2003; Skyner *et al* 2004; Mallapur in press), reproductive fitness (Glatson *et al* 1984; Rendall & Taylor 1991; Mootnick & Baker 1994; Lukas *et al* 2002; Buchanan-Smith *et al* 2004; Prescott & Buchanan-Smith 2004) and preference testing (Hosey *et al* 1999).

Most studies using behaviour to assess the welfare of primates in zoos record the levels of abnormal behaviour exhibited by the study animals (Lukas 1999; Waitt &

Buchanan-Smith 2001; Mallapur & Choudhury 2003; Blaney & Wells 2004). For example, in a study on the behaviour of captive primates housed in Indian zoos, levels of abnormal behaviour exhibited were recorded in order to identify the factors that influenced the animals' behaviour (Mallapur & Choudhury 2003). In some studies, behaviour is recorded along with other indicators of welfare. For example, Rendall and Taylor (1991) recorded sexual behaviour and the reproductive success of all individuals within a group of captive Japanese macaques (*Macaca fuscata*). This approach was used to devise a way of improving the welfare of the captive individuals so as to establish a self-sustaining captive population.

Other methods used to assess and improve the welfare of zoo primates are preference testing (Fraser & Matthews 2000; for example Hosey *et al* 1999). In their study on captive common marmosets (*Callithrix jacchus jacchus*), Hosey *et al* (1999) tested for the preference of nest box size and position by introducing two new wooden boxes to the animal's enclosure. The study showed that the marmosets had a strong positional preference; they also preferred the high nest boxes.

So far there has been a dearth of information on assessing and improving the welfare of captive lion-tailed macaques. Since species-specific indicators are used to assess the welfare of captive primates (Buchanan-Smith *et al* 2004; Prescott & Buchanan-Smith 2004), it would be imperative to identify welfare indicators to assess the welfare of the lion-tailed macaque in order to establish a self-sustaining captive population in Indian zoos.

8.3. AIM

The aim of this study was to identify factors that could be used to assess the welfare of lion-tailed macaques housed in Indian zoos. This study also intends to standardise a comprehensive list of welfare indicators that could be used together to assess the welfare of each individual macaque.

8.4. METHODOLOGY

8.4.1 General methods

A study was conducted on 51 lion-tailed macaques across 13 Indian zoos, to identity indicators of poor welfare. Twelve variables were chosen, of which abnormal behaviour and rearing history were already documented in detail in Chapter IV and an individual's current ability to breed in Chapter VII. The 12 variables recorded were:

8.4.1.1. Body Condition

Six variables were recorded in this category in order to assess each individual's welfare. They were:

1.Movement: an individual's ability to move with ease

2.Mass: the body mass of each individual was graded on a scale from fat to thin. The body mass of each individual was also graded on sagging form, especially the stomach.

3.Fur Condition: the coat of each individual was graded on a scale from smooth and shiny to scraggly and unkempt.

4.Body size: each individual's body size was graded from small to large

5.Body weight: observed body weights were recorded for each individual. Two veterinarians and the observer individually assessed the weights of each individual at each zoo. The final observed weight recorded was the average of the three estimates. This method was used in order to reduce stress bias, which could be caused while capturing the animal to measure its weight.

6.Disability: any permanent or temporary deformity or disability was also recorded as a possible indicator of welfare.

8.4.1.2. Behaviour and Health

Three variables were recorded in this category in order to assess each individual's welfare. They were:

1. Disease incidence: individuals that suffered from an illness during the period of the study (June 2002 to January 2004) were given a different health grade in comparison to those who did not.
2. Abnormal behaviour:
   i. Durations of abnormal behaviour: the actual durations of abnormal behaviour exhibited, and
   ii. Frequencies of abnormal behaviour: the actual frequencies of abnormal behaviour exhibited by each individual were used to test against the other variables during data analyses.

8.4.1.3. Demographic details

Certain demographic variables were also used to assess the welfare of captive lion-tailed macaques. The variables used were:

1. Age: age could be an indicator of poor welfare in primates where, in some cases, older animals drop in the hierarchy, which could prove to be stressful (deVries *et al* 2003). Age was recorded from studbook information maintained at each zoo.
2. Current ability to breed: individuals, both males and females, were categorised into "proven breeders" if they have bred at least once over the last five years. Those that did not were classed as "non-breeders". The information on each individual's breeding history was recorded from the studbooks maintained at each zoo.
3. Rearing History: an animal's rearing history was ranked for data analyses, with one for animals caught from the wild and four for animals that were confiscated from private owners and brought to the zoo (refer to Section 2.1.3. *Study Animals* in Chapter II *General Methods*).

8.4.2 Data analyses

Of the 12 variables listed above, eight were ranked for data analyses (Table 8.1). The remaining four variables were age, body weight, durations and frequencies of Table

8.1. The 12 variables used to assess the welfare of captive lion-tailed macaques housed in Indian zoos. Of these, eight were ranked and actual values were used for the remaining four.

Welfare Indicator	Category	Rank[1]
1. Movement	Move very slowly with a lot of difficulty	1
	Move slowly with a little difficulty	2
	Move normally with no difficulty	3
2. Body mass	Stomach sagging excessively	1
	Stomach sagging slightly	2
	Stomach taut	3
3. Fur condition	Shaggy with many scars and bald patches	1
	Coat unkempt but no scars or bald patches	2
	Coat smooth, shiny and continuous	3
4. Body weight[2]		
5. Body size	Small	1
	Medium	2
	Large	3
6. Age[2]		
7. Durations of abnormal behaviour[3]		
8. Frequencies of abnormal behaviour[3]		
9. Current ability to breed	Non-breeders	1
	Proven breeders	2
10. Rearing history	Wild Caught	1
	Captive Reared	2
	Zoo Born	3
	Confiscated	4
11. Disability	Permanently disabled or deformed	1
	Temporarily disabled or deformed	
	Normal with no disability or deformation	2
12. Disease incidence	Suffered from ill health during study period	1
	Did not suffer from ill health during study period	2

[1]The ranks were only used for data analyses using principal component analysis.
[2]In the case of age and body weight, actual ages and weights were used for analysis.
[3]Actual percentages and frequencies were used for durations and frequencies of abnormal behaviours respectively

abnormal behaviour exhibited, for which actual values were used for data analyses (Table 8.1). In order to identify variables that account for the greatest proportion of variability in the Indian captive lion-tailed macaque population, the principal component analysis (PCA) was used (see Sokal & Rohlf 1995). PCA is a multivariate methods designed to transfer a set of interrelated variables into a new set of uncorrelated components which accounts for all the variance in the original variables (http://www.public.asu.edu/~pythagor/ principal_component.htm, 17th July 2004, 15:38). In this study, the PCA was used to reduce the number of original variables in the data set. This was done by finding the smallest set of principal components, which explain most of the variance in the data set. Each principal component is a linear combination of its variables (Sokal & Raulf 1995). The first principal component accounts for the maximum variance in all the variables. The amount of variance of each new component is indicated by the 'eigenvalue'. During the initial PCA, a scree plot was designed. A scree plot is obtained by plotting the eigenvalues associated with each factor on a graph. The purpose of a scree plot is to determine how many factors to retain for following PCAs (Cattell *et al* 1984). This was done by retaining all the eigenvalues (and hence components) in the sharp descent of the graph before they start to level off. In the subsequent PCA, component plots were designed by plotting the rotated factor loadings of one factor against another. In the plot, the factor loadings of each variable are represented as a point. In this plot, the axes could be rotated in any direction without changing the relative location of the points to each other. The purpose of rotating these points is to obtain a clear pattern of loadings of those marked by high loadings and the others that are marked by low loadings.

8.5. RESULTS

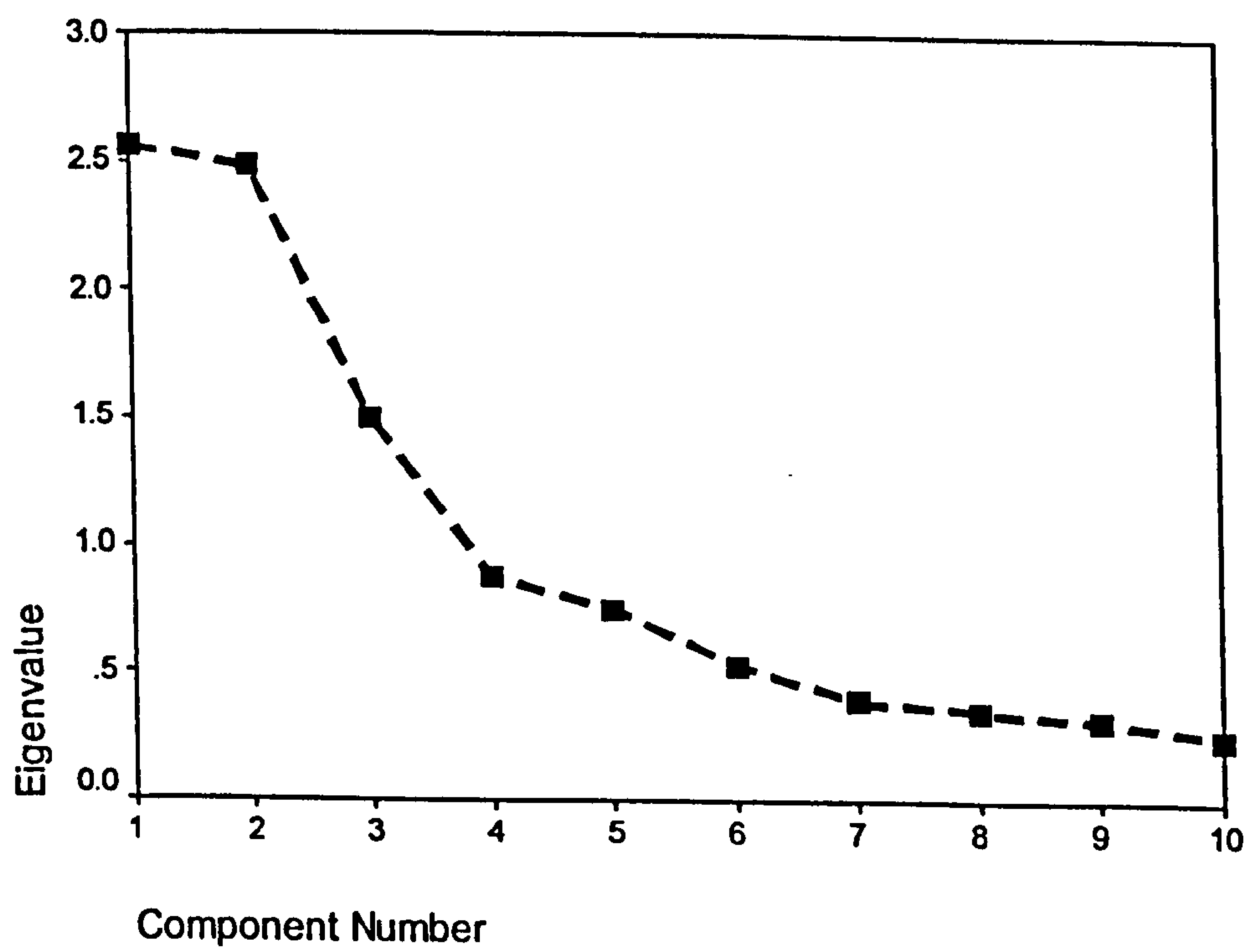
The first step of the data analyses was to identify variables (of the 12 listed above) that accounted for the greatest proportions of the variance and exclude those variables that influence the data negligibly. This was done by designing a scree plot using principal component analysis (refer to section 8.4.2 *Data Analyses*; Figure 8.1).

The preliminary PCA conducted suggested that the first 10 variables accounted for approximately 65% of the variance and were used for subsequent factor analysis. The 10 variables are listed below

1. Body mass (BM)
2. Body size (BS)
3. Current ability to breed (B)
4. Fur condition (FC)
5. Movement (M)
6. Age (A)
7. Weight (W)
8. Rearing history (RH)
9. Duration of abnormal behaviour (DAB)
10. Frequency of abnormal behaviour (FAB)

The initial principal component analysis determined three factors that had eigenvalues equal to or greater than 1, which accounted for 65% of the variance (Figure 8.1). These three factors were used for subsequent PCA.

Figure 8.1 Scree plot for initial 10 factors



Rotating the first three factors gave factor loadings for each variable. Rotated factor 1 (eigenvalue 2.56) accounted for 26% of the total variance and the variables that loaded heavily for this factor (factor loading of > ± 0.5) were 'movement', 'body mass', 'fur condition' and 'age'. While 'movement', 'body mass' and 'fur condition' loaded positively, 'age' loaded negatively on factor 1 (Table 8.2). This factor was called the 'physical-condition factor'.

Table 8.2. Factor loadings for each variable

Variables	Factor 1	Factor 2	Factor 3
Movement (M)	**0.786***	0.052	0.390
Body mass (BM)	**0.738**	0.285	-0.103
Fur Condition (FC)	**0.670**	0.293	0.380
Age (A)	**-0.746**	0.345	0.110
Body weight (W)	-0.498	0.428	**0.613**
Body size (BS)	-0.156	0.008	**0.829**
Rearing history (RH)	0.026	**0.652**	-0.258
Current ability to breed (RS)	0.246	**-0.695**	0.210
Durations of abnormal behaviours (DAB)	0.236	**0.631**	-0.047
Frequencies of abnormal behaviours (FAB)	0.036	**0.838**	-0.078
% Variance accounted for	26	24	15

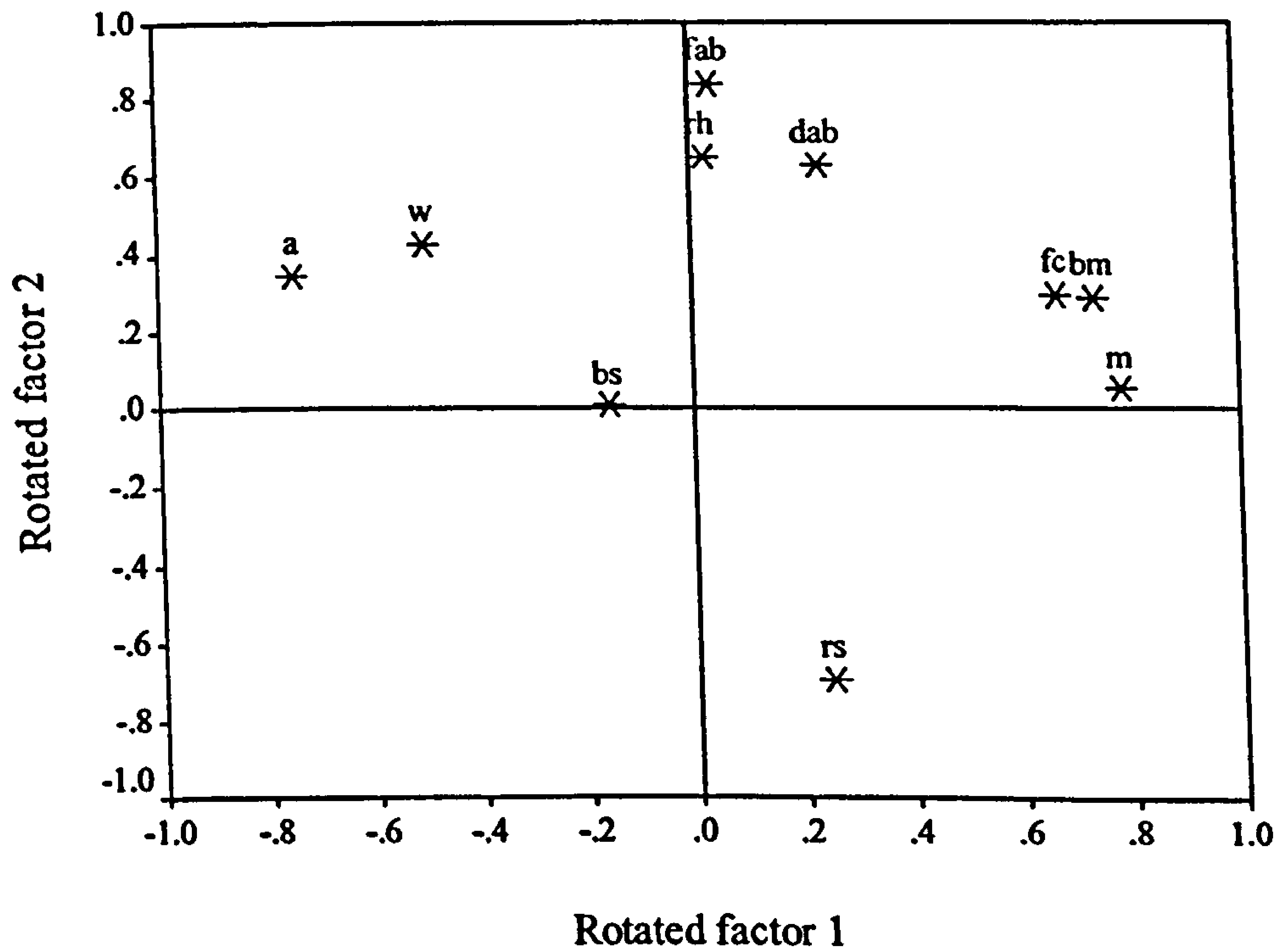
* Factor loadings shown in bold show the variables that significantly influence that factor

Rotated factor 2 (eigenvalue 2.48) accounted for 24% of the total variance. The variables 'rearing history' and 'durations' and 'frequencies of abnormal behaviour' heavily loaded positively on this factor while the variable 'current ability to breed' loaded negatively (Table 8.2). This factor was called the 'developmental and reproductive success factor'.

Rotated factor 3 (eigenvalue 1.5) accounted for 15% of the total variance and heavily loaded positively for the variables 'weight' and 'body size' (Table 8.2) and was termed the 'morphometric factor'.

The relationships between the variables have been shown by plotting the rotated loadings of two factors in each graph (Figures 8.2 & 8.3).

Figure 8.2 Factor loadings for each variable on factors 1 and 2

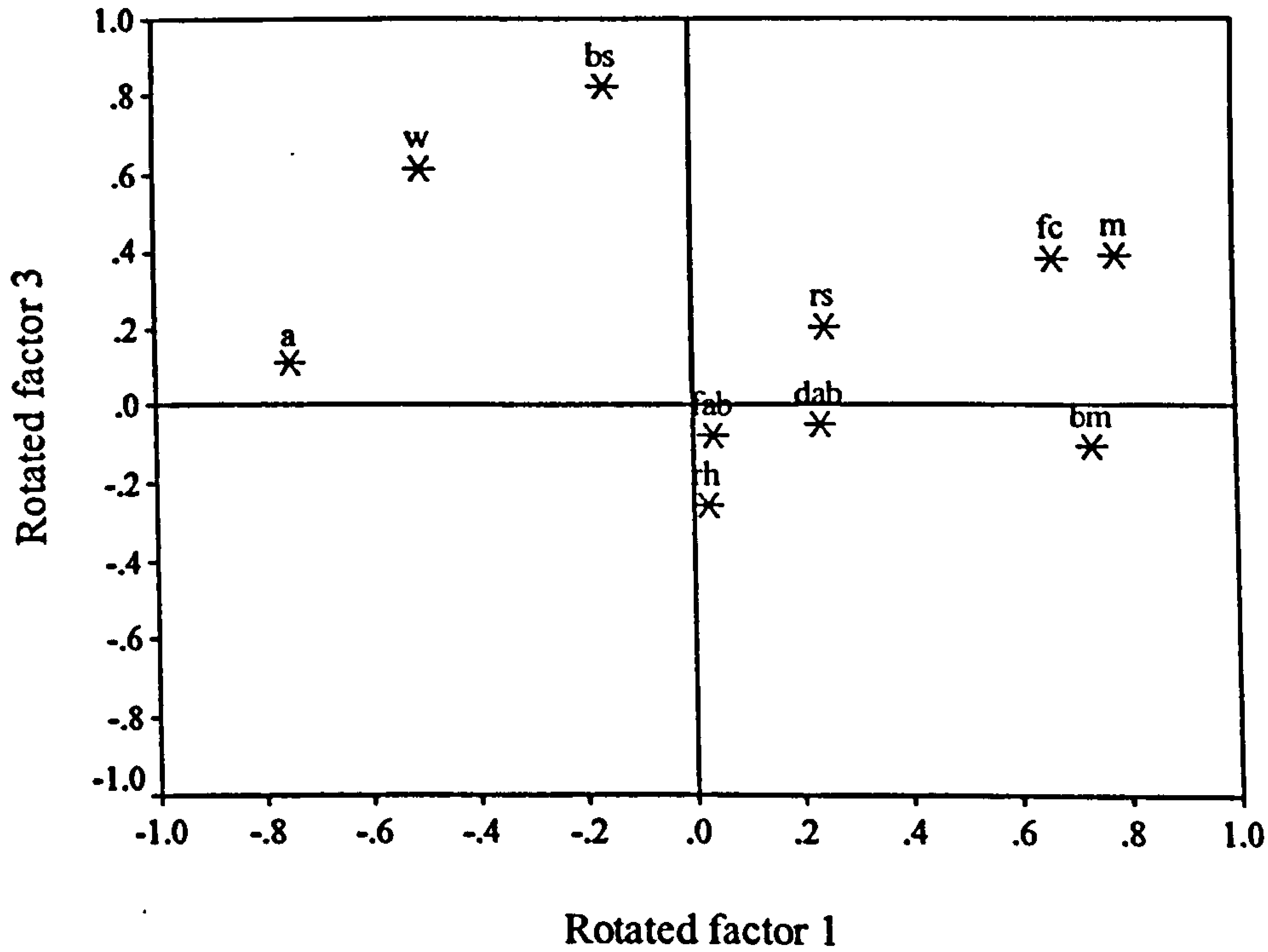


(Refer to Table 8.2 for abbreviations)

8.5.1. Factor 1 vs. Factor 2

In Figure 8.2 (Refer to Table 8.2 for abbreviations) the rotated loadings of factors 1 and 2 have been plotted in the form of a graph. The three variables that heavily loaded positively of factor 1 were 'movement' (M), 'body mass' (BM) and 'fur condition' (FC), while 'age' (A) heavily loaded negatively on factor 1. Hence, although all four variables had a strong influence on factor 1, the first three (movement, body mass and fur condition) and 'age' were acting in opposite directions. This further suggests that when the rank for the variables 'movement', 'body mass' or 'fur condition' was low (for example 1; refer to Table 8.2 for ranks), the 'age' of the animal in question was high and vice versa.

Figure 8.3 Factor loadings for each variable on factors 1 and 3



(Refer to Table 8.2 for abbreviations)

Three variables – 'rearing history' (RH), 'durations' (DAB) and 'frequencies of abnormal behaviour' (FAB), heavily loaded positively on factor 2 while 'current ability to breed' (B) heavily loaded negatively on factor 2. Hence, although all four variables had a strong influence on factor 2, the first three (rearing history, durations and frequencies of abnormal behaviour) and 'current ability to breed' were acting in opposite directions. Hence when the rank for 'current ability to breed' was the highest (for example 2; refer to Table 8.2 for ranks), the 'rearing history rank' was the lowest (for example 1; refer to Table 8.2 for ranks) and vice versa. Similarly, when the rank of 'current ability to breed' was high (for example 2; refer to Table 8.2 for ranks), the 'durations' and 'frequencies of abnormal behaviour exhibited' by the individual in question was low. However, with the increase in the rearing history ranks, the durations and frequencies of abnormal behaviour also increased (refer to Table 8.2 for ranks).

8.5.2. Factor 1 vs. Factor 3

Figure 8.3 (Refer to Table 8.2 for abbreviations) shows the rotated loadings of factor 1 plotted on a graph against the rotated loadings of factor 3. The two variables that heavily loaded positively on factor 3 were 'body size' (BS) and 'body weight' (W). Hence, with the increase in body size rank the actual body weight of the individual in question increased (refer to Table 8.2 for ranks).

8.6. DISCUSSION

Twelve variables were chosen in order to identify a group of factors, which could be used to assess the welfare of captive lion-tailed macaques. Since the lion-tailed macaques were a part of a breeding programme, only some 'non-invasive' and 'hands-off' measurements were used for assessing their welfare. However, physiological indicators and parasite load, which would have strengthened the study, were not measured due to logistical constraints. Of the 12, 10 variables accounted for the greatest proportion of variability between the 51 lion-tailed macaques observed across 13 Indian zoos.

The first group of variables that accounted for 26% of the variability in the Indian captive lion-tailed macaque population were 'movement', 'body mass', 'fur condition' and the individual's 'age'. Lion-tailed macaques that had difficulty in moving from one part of the enclosure to another, had a sagging stomach and musculature and/ or had a shaggy coat with bald patches, were older than individuals who could move without any difficulty, whose musculature was taut and who had a smooth and continuous coat.

Physical-condition factors have been used in the past to assess the health and welfare of farm and laboratory animals (Anderson & Visalberghi 1990; Fraser & Broom 1997; Hughes & Curtis 2000; for example Webster *et al* 2004). Veterinarians universally use an animal's physical condition as the first indicator of its health status

(Anderson & Visalberghi 1990; Hughes & Curtis 2000). In their study on welfare indices for dairy cows and hens, Webster *et al* (2004) devised a comprehensive animal welfare assessment protocol, which included several parameters of physical appearance. These included body condition, feather loss, injuries on limbs and skin for the study on laying hens and body condition, hair loss and external injuries for the study on dairy cows. In this study on captive lion-tailed macaques, the 'physical-condition factor' was found to be suitable to assess welfare. Two or more variables from within this group could be used together to assess welfare (for example age and fur condition) or some 'physical-condition factor' could also be used along with some 'developmental and reproductive success factor' (for example age and fur condition from the 'physical-condition factor' and current ability to breed and rearing from the 'developmental and reproductive success factor').

The 'developmental and reproductive success factor' included four variables – the individual's 'current ability to breed', 'rearing history', 'durations' and 'frequencies of abnormal behaviour exhibited'. This group accounted for the second greatest proportion of variability in the captive lion-tailed macaque population housed in India. An individual's ability to breed was inversely proportionate to the other three factors. Hence, non-breeding lion-tailed macaques tended to be the animals that were confiscated from private owners. They also exhibited higher percentages and frequencies of abnormal behaviour than wild-caught or captive-reared individuals.

Studies have shown that early social deprivation (rearing history) could influence an animal's ability to cope with its current artificial environment (for example Anderson & Chamove 1980; Chamove *et al* 1984; Anderson & Chamove 1985; Mootnick & Baker 1994). In this study on captive lion-tailed macaques, individuals that were confiscated from private owners exhibited significantly greater levels of abnormal behaviour and aggression than zoo-born, captive-reared and even wild-caught individuals (refer to Chapter IV). An individual's rearing history also correlated with the animal's current ability to reproduce (referred to as breeding in previous chapters; refer to Chapter VII). Reproductive success has also been used to assess the welfare of animals of different species housed in laboratories, farms and even zoos (Duncan

& Fraser 2000; Clubb & Mason 2001; Buchanan-Smith *et al* 2004; Webster *et al* 2004). Even so, the commonly used indicator of welfare is behaviour (Mason 1991; Mason & Latham 2004).

Several zoo animal studies have used abnormal behaviours to assess the welfare of wild animals in captivity (Chamove *et al* 1984; Fritz *et al* 1992; Marriner & Drickamer 1994; Mootnick & Baker 1994; Buchanan-Smith 1996, 1997; Worlein & Sackett 1997; Lukas 1999; Mallapur & Choudhury 2003; Mallapur in press). However, animal welfare scientists have cautioned the use of abnormal behaviour as an indicator of poor welfare, the main reason being that abnormal behaviours, especially stereotypies, sometimes remain as 'scars' of past sub-optimal conditions, and hence persist in circumstances that improve welfare (Mason 1991; Mench & Mason 2000; Mason & Latham 2004). Stereotypies may even increase in response to changes that can be presumed positive for welfare (Mason & Latham 2004).

Animal welfare is maintained on a continuum between poor and good (Mason 1991). In most modern zoos in America and Europe, well balanced management and husbandry protocols followed have resulted with the improvement of the welfare of captive wild animals. At present, the proportion of captive animals in these zoos that exhibit abnormal behaviours is considerably lower and almost non-existent (for example with reference to zoo primates in Europe, Lindsey Skyner, *pers. comm.*). However, in Indian zoos, the welfare of captive wild animals (for example captive lion-tailed macaques in this study) is closer to the 'poor' end of the welfare continuum.

In order to design an unbiased, comprehensive method to assess the welfare of captive lion-tailed macaques in these zoos, a combination of factors from 'physical condition' and 'developmental and reproductive success' parameters can be used. Using several indicators together to assess the welfare of captive animals has also been reiterated in literature (Mench & Mason 2000; Buchanan-Smith *et al* 2004; Mason & Latham 2004; Webster *et al* 2004) and specifically age, rearing history and gender in the case of assessing the space requirements of captive primates (Buchanan-

Smith *et al* 2004; Prescott & Buchanan-Smith 2004). Apart from using several indicators together to obtain realistic and convincing assessments of welfare, it was considered imperative to standardise species-specific indicators while conducting this study on captive lion-tailed macaques, in order to maximise the possibility to improving the welfare of each individual.

8.7. CONCLUSIONS

The 'physical-condition factor' and the 'developmental and reproductive success factor' were of particular importance in this study. The 'physical-condition factor' included the welfare indicators movement, body mass, fur condition and age while 'developmental and reproductive success factor' included rearing history, current ability to breed, durations and frequencies of abnormal behaviours exhibited. These indicators are most suitable to assess the welfare of lion-tailed macaques or even other species of primates in zoos since they are 'hands-off' and 'non-invasive' which is an important consideration, especially when assessing the welfare of wild animals that are a part of, or are going to be a part of, a breeding programme which aims to reintroduce them into their natural habitat. However, it would be important to note that no physiological measurements were used to assess the welfare of lion-tailed macaques, as they were invasive.

CHAPTER IX *General Discussion*

CONTENTS

9.1. INTRODUCTION

This study was initiated due to the concerns over the problems regarding breeding success of lion-tailed macaques housed in Indian zoos. Since the commencement of this study in June 2002, only three individuals have been born, all at Arignar Anna Zoological Park. Individuals housed at the 12 other zoos have not bred over the past two years. With these low recruitment rates, the Indian captive population for this species consists of a greater proportion of adults than infants and juveniles. The absence of basic and applied research has made it difficult for the zoo community to understand and identify the problems affecting the breeding success of this species. Therefore, there is a need to understand and identify the factors influencing the current captive population's breeding success. The aims of this study were three fold: firstly to identify the factors that influence behaviour, secondly to examine the difference between breeding and non-breeding groups, and finally to administer enrichment and to identify indicators to assess the welfare of lion-tailed macaques in captivity.

9.2. PRELIMINARY SURVEYS

The absence of primary data on management and husbandry of the Indian captive lion-tailed macaque population and poorly maintained studbooks required the first stage of the study. Preliminary surveys were carried out in order to collect baseline data on the behaviour, management and husbandry of this species in captivity both in India and other international zoos and also to construct an ethogram. The information collected from the questionnaire survey for the international zoo community helped to identify factors that may influence the behaviour and welfare of lion-tailed macaques in captivity. These factors were identified by recording the differences in enclosure design, behavioural monitoring and management, primate husbandry and management, diets, size and composition of groups, demography and breeding success between the Indian and international zoo communities.

The questionnaire survey (refer to Chapter III) proved useful in that it identified the following factors; - group composition, enclosure design, dietary preparation and nutrition, and visitor-animal interaction as those that may influence the behaviour and breeding success of captive lion-tailed macaques. Interestingly, most of the zoos outside India are situated. However, although Indian zoos being situated in a tropical region are more conducive to house lion-tailed macaques, the reproductive success of individuals housed in zoos situated in the temperate regions of the world especially in North America and Europe were significantly greater than that of those housed in India. Similarly, animal keepers in Indian zoos feed these animals with fresh foods some native to the animals' natural habitat such as vegetables, fruits and browse, which is, supplied daily in comparison to the commercial primate pellet used in zoos outside India. This suggests that behaviour and welfare problems faced by captive lion-tailed macaques in Indian zoos could be influenced by poor zoo husbandry and management.

The influence of the above mentioned factors on the behaviour of this species were further investigated by conducting a behavioural survey across Indian zoos housing the species. Abnormal behaviour has been used in several studies as an indicator of poor welfare (Mason & Latham 2004; eg Clarke *et al* 1982; Goerke *et al* 1987; O'Neill *et al* 1991; Mallapur & Choudhury 2003; Skyner *et al* 2004; Mallapur in press). The results of the behavioural survey showed that the factors; enclosure design and rearing history, had the strongest influence on behaviour. Although endangered, endemic species such as the lion-tailed macaque are to be given first priority with regard to space and social requirements, several Indian zoos still house this species in small, barren cages. Most of the zoos in India that house the lion-tailed macaque are large in size; however, a considerable proportion of the space within these captive facilities is converted into lawns, foot-paths and gardens for the visiting public. Also, zoos usually have one large exhibit per species with several small cages for surplus animals. Since lion-tailed macaques are housed in polygynous associations in captivity, Indian zoos having more than one male tend to house their male surpluses in small cages.

9.2.1. Influence on enclosure design on behaviour

Enclosure design influenced both durations and frequencies of foraging behaviour exhibited by the lion-tailed macaques. Individuals housed in cages with no structural features and a hard substrate foraged significantly less than animals housed in complex, open-moated enclosures with a soft substrate. This could very well be due to the absence of appropriate environmental stimuli in cages with no structural features such as trees, logs, bushes or even a water body, which provides surplus browse and also attracts insects and other invertebrates. It is imperative to note that different types of foraging were influenced by various features of the captive environment. For example, lion-tailed macaques housed in complex environments actively foraged more than those housed in barren enclosures. The presence of trees, shrubs and water bodies could have influenced this behaviour change. Similarly, individuals housed in dry-moated enclosures passively foraged for greater proportions of time than those housed in wet-moated enclosures or cages. Individuals would forage on the ground in the dry moats for considerable durations of time. This might be due to the dry moat being a hideout out of the view of the visiting public. Enclosure substrate also influenced foraging with animals housed on soft substrate such as grass foraging for insects more than those housed on hard substrates. Grass tends to attract several types of invertebrates and this could be the reason behind the increased levels of foraging on this substrate.

Enclosure design also influenced the levels of aggression exhibited by individuals maintained in groups. Animals housed in smaller enclosures with no structural features exhibited higher levels of agonistic behaviour towards other members of their group compared to groups housed in large, moated complex enclosures. Smaller enclosures with no structural features may have less space allowance per individual than a large, complex one, thus leading to crowding. Crowding in captive primates has been found to increase levels of aggressive behaviour exhibited toward one another (Elton 1979; Erwin 1979; Judge *et al* 1997). The main reason for an increase in aggression levels in small crowded enclosures would be the reduced flight distances of subordinate animals from dominant animals. In a small enclosure, one way to improve this is through the provision of temporary barriers. This could lead to a reduction in levels of aggression exhibited by captive primates (eg Estep & Baker 1991) by providing hide-outs for lower-ranking animals and also by increasing flight distances giving these individuals a chance to escape agonistic interactions. For example, in a study conducted on a group of captive stump-tailed macaques (*Macaca arctoides*), the provision of temporary cover (two temporary walls within the enclosure) significantly reduced levels of contact aggression exhibited within the group (Estep & Baker 1991).

9.2.2. Influence of rearing history on behaviour

Lion-tailed macaques that were confiscated from private owners exhibited relatively higher levels of abnormal behaviour than individuals that were zoo-born, while captive-reared and wild-caught individuals did not exhibit any abnormal behaviours. In southern India lion-tailed macaques are caught for pet trade (Walker & Molur 2003) leading to them being in close contact with humans. These animals are later rescued by forest department and transferred to the nearest zoo. These animals were probably caught as infants and reared in isolation (in the absence of conspecifics) leading to the display of several forms of aberrant behaviours. Long-term contact with humans at an early age is known to be detrimental to normal behavioural development. Primates are considerably dependent on maternal care during infancy (Erwin & Deni 1979). From birth, appropriate social behaviour is important for primate development. The development of several group-appropriate behaviours, such as reproductive and affiliative behaviours (Erwin & Deni 1979; Carlstead 1996) is learnt at an early age. In the absence of conspecifics, abnormal behaviours will develop and appear to replace more normal activities such as play, reproductive behaviour, maternal behaviour and exploration (Erwin & Deni 1979; Anderson & Chamove 1980; Chamove *et al* 1984; Anderson & Chamove 1985; Mootnick & Baker 1994). Some of the abnormal behaviours most commonly exhibited by captive lion-tailed macaques in this study were 'stereotypic pacing', 'floating limb' and 'self-biting'. Self-mutilatory behaviours have been observed to develop due to early social deprivation (Anderson & Chamove 1980; Chamove *et al* 1984; Anderson &

Chamove 1985; Mallapur & Choudhury 2003). These and other abnormal behaviours occur in situations when the animal lacks control over its environment (Fraser & Broom 1997). Behaviours such as these may increase sensory input levels in sub-optimal environments by producing a more familiar and predictable input in order to alleviate the effects of adverse conditions.

The preliminary surveys proved useful in identifying the factors that influenced the behaviour of captive lion-tailed macaques and could be used to provide base-line information for the design of long-term behavioural and welfare studies regarding in the management of breeding colonies of this species. However, the design of the behavioural aspects of this study in a zoo setting proved challenging due to the high degree of variability in the zoo environment and the associated impact on behavioural data. Several confounding factors are likely to have influenced the behaviour of the captive lion-tailed macaques simultaneously. In order to overcome these difficulties, partial correlations were used to study the influence of one factor while keeping the other factors constant (Chapter IV).

9.3. STRUCTURAL AND SOCIAL ENRICHMENT

The second objective of this study was to design cost-effective enrichment that would improve the welfare of captive lion-tailed macaques in Indian zoos. It was decided that enrichment that reduced abnormal behaviour levels and increased natural behaviours exhibited by the captive individuals would be beneficial to the animal's welfare. Since confiscated and some zoo-born lion-tailed macaques exhibited abnormal behaviours (refer to Chapter IV), it was also decided that only confiscated animals would be used for the enrichment studies. The term 'environmental enrichment' is vague and there have been several definitions that have been put forth to explain this concept (Newberry 1995). In this study, Newberry's (1995) definition has been used (for definition, refer to Chapter I, Section 1.5.4 Methods of improving primate welfare).

Of the two enrichment studies that were conducted, one involved structurally enriching the main enclosure while the second aimed at providing a combination of structural and social enrichment to previously singly-housed lion-tailed macaques. In the enrichment study, an 'A-B-C-B-A' experimental design was used to examine whether a) abnormal behaviours reduced and exploratory behaviours increased from A to C and B) abnormal and exploratory behaviours returned to their original levels during the experiment phases C to A. In both studies, levels of abnormal behaviour exhibited by the lion-tailed macaques were significantly higher before the change (that is, when the individuals were singly-housed in barren cages) than after the change had taken place (addition of structural features or group-housing in a complex enclosure). This suggested that changing the attributes of the existing enclosure or transfer to a new enclosure with group-housing provided more appropriate environmental stimuli for stimulating these previously singly-housed macaques to exhibit more natural behaviours such as foraging. In the first enrichment study, the provision of ropes to the singly-housed lion-tailed macaques resulted in some individuals apparently redirecting their self-biting behaviour to the ropes. When the feeding basket was added, the level of abnormal behaviours exhibited reduced further. The results of this study coincide with other studies where the transfer of animals to more complex enclosures led to the reduction of previously exhibited abnormal behaviours (Clarke *et al* 1982; O'Neill *et al* 1991). In another study on social enrichment of isolated rhesus macaques, the introduction of weaned juvenile rhesus macaques to adults reduced levels of stereotypic behaviour exhibited by these adults. This suggested that pair-housing of previously singly-housed macaques improved their welfare by providing social contact and social interactions (Reinhardt *et al* 1995). Zoo animals usually exhibit abnormal behaviours when they are housed in sub-optimal environments that restrict them from exhibit species-specific behaviours (Erwin & Deni 1979; Chamove *et al* 1984; Anderson & Chamove 1985; Mitchell *et al* 1987; Rendall & Taylor 1991; Marriner & Drickamer 1994; Reinhardt 1997; Mallapur & Choudhury 2003; Mallapur in press). In this study, provision of any form of environmental enrichment, for example adding cotton ropes and feeding basket into the enclosure, and conspecifics, provides the appropriate stimuli which improves the biological functioning of these individuals. Improvements by modifying the captive environment in this study include a decrease in the abnormal behaviours exhibited.

Similarly, in both enrichment experiments, the change in the captive environment resulted in an increase in foraging and exploratory behaviours. The addition of a feeding basket in phase 3 of the first enrichment study and the transfer to a complex enclosure with more trees, bushes and a body of water provided the lion-tailed macaques with the appropriate environmental stimuli which may have motivated them to exhibit more natural foraging behaviours. Similarly, in a study on a group of captive hanuman langurs (*Semnopithecus entellus*), Little and Sommer (2002) recorded a significant difference in the behaviours exhibited by the langurs before and after their transfer to a new enclosure. In the new complex, naturalistic enclosure, langurs exhibited higher levels of feeding and locomotory behaviours while aggressive and resting behaviours decreased. The provision of feeding basket and the transfer to a complex enclosure with trees, stimulated the captive lion-tailed macaques in this study to exhibit natural feeding and foraging behaviours. Provision of fresh browse also led to an increase in foraging behaviour, in captive orang-utans (*Pongo pygmaeus*) at Chester Zoo (Birke 2002). Birke (2002) observed that adult orang-utans spent more time foraging for small food items in the woodchip substrate provided beneath the branches of their browse than before the browse was provided. Provision of browse in this study provided the necessary environmental stimuli required to stimulate the captive lion-tailed macaques to exhibit natural feeding and foraging behaviours. Feeding enrichment specially proves successful in increasing levels of feeding and foraging behaviours exhibited in environments in which there previously has been a total absence on foraging material rendering these animals incapable of foraging. Modifying enclosures is also known to increase levels and the diversity of natural behaviours exhibited, lifetime reproductive success, inclusive fitness and also improves health (Newberry 1995).

These enrichment studies showed that captive lion-tailed macaques, despite having had a poor rearing history and being housed for sometime in barren enclosures, often singly, are capable of displaying a natural behavioural repertoire when provided with the appropriate environmental stimuli. These studies should prove useful for updating guidelines used to manage lion-tailed macaques in Indian zoos. These enrichment studies could also be used to train animal keepers in designing appropriate structural enrichment and also choosing individuals for group housing. However, only confiscated animals that were housed in enclosures of similar design (similar enclosure sizes, substrates, complexities and types; for definitions of these variables, refer to Chapter II) were chosen for the enrichment studies. This resulted in a relatively small sample of animals (six for the structural enrichment study and six for the social enrichment study) being available for observation. Whilst it is possible to carry out analysis on this sample size, the results would be more convincing if greater numbers could be utilised or better statistical tools for this type of research were available. The need for stronger statistical tools has been constantly reiterated in zoobiological science (Zoo federation research group, *pers. comm.*). The use of a powerful multi-factorial statistical test that can be used to test non-normal, highly variable behavioural data would have allowed the use of a larger subset of the original (eg individuals that were confiscated, zoo-born, captive-reared and wild-caught) sample or perhaps even the entire sample. By conducting the enrichment studies on a larger subset of the original population sampled, the behavioural differences between the various sub-groups (eg individuals that were confiscated, zoo-born, captive-reared and wild-caught) could also be recorded.

9.4. VISITOR INFLUENCE AND PERCEPTION

The questionnaire survey also demonstrated that visitor-interaction may influence the behaviour and reproductive success of captive lion-tailed macaques. Hence, the third objective of this study was to determine the influence of visitor presence of the behaviour and welfare of captive lion-tailed macaques and to assess the educative influence of Indian zoos on their visiting public.

9.4.1. Visitor influence on behaviour

The visitor presence studies showed that the captive macaques exhibited higher levels of abnormal behaviour during visitor presence than when visitors were absent. Certain types of abnormal behaviour such as nipple licking, regurgitation and reingestion were only exhibited during the presence of visitors. These behaviours were not exhibited during the absence of visitors. Interestingly, visitor presence has been shown to have a significant influence on the behaviour of captive primates (Chamove *et al* 1988; Hosey & Druck 1987; Mitchell *et al* 1991; Hosey 2000; Birke 2002; Blaney & Wells 2004; Skyner *et al* 2004). In a study on captive mandrills (*Mandrillus* spp.), Chamove *et al* (1988) observed that the presence of visitors led to a marked increase in abnormal behaviours exhibited by the animals. Skyner *et al* (2004) found a similar increase in levels of self-biting exhibited by a male pileated gibbon (*Hylobates pileatus*). In a study on captive gorillas (*Gorilla gorilla gorilla*) at Belfast Zoo, camouflage netting was fitted on the visitor-side of the glass-fronted exhibit to act as a visitor barrier (Blaney & Wells 2004). The gorillas were found to exhibit lower levels of abnormal behaviour after the camouflage netting was added than before it. It is only fairly recently that zoo biologists have become aware of just how much a zoo animal's behaviour can be influenced by visitors. The effect may be subtle in that the animals are less active, but the impact can be much greater, for example a reduction in normal sexual activity. Such visitor barriers or even accessibility to the vertical dimension through logs and ropes could be provided in the lion-tailed macaque exhibits in order to give the lion-tailed macaques an option of hiding from the public has been (refer to Section 9.9 *Conclusions*).

In this study on captive lion-tailed macaques, visitor presence was also found to significantly influence levels of social interactions, especially reproductive behaviours. Levels of social behaviours exhibited by captive primates have been shown to be influenced by the presence of visitors (Chamove *et al* 1988; Glatson *et al* 1984). For example, in a study on captive cotton-top tamarins (*Saguines oedipus*), social behaviours were recorded in a group that was displayed to the zoo visiting public and compared with that of a group housed in an off-exhibit breeding facility

(Glatson *et al* 1984). The study showed that the proportions and frequencies of social interactions displayed by the group on-exhibit were significantly less than that of the breeding group housed off-exhibit.

Visitor presence also appears to influence levels of aggression in captive primates (Chamove *et al* 1988; Mitchell *et al* 1991; Blaney & Wells 2004). Blaney and Wells (2004) studied the influence of visitor presence on a group of captive gorillas when a camouflage barrier was placed on the visitor side of the enclosure. The study showed that levels of aggressive behaviours directed towards conspecifics decreased. In the current study on captive lion-tailed macaques, visitor presence was also found to significantly influence aggressive behaviours exhibited towards conspecifics, with higher levels of aggressive behaviours being exhibited when visitors were present.

This is the first study that has demonstrated a visitor effect on the behaviour of captive lion-tailed macaques. The relatively large sample size in Study 1 (refer to chapter VI Study 1A) of 30 animals facilitated the detection of the influence of visitor presence on levels of both abnormal and normal behaviours exhibited and the use of enclosure space by macaques. Even in Study 2 (refer to Chapter VI Study 1B) in which a smaller sample of lion-tailed macaques were observed (N = 7), visitor presence was found to be linked to increased levels of abnormal behaviours and decreased levels of more natural behaviours. In this study, the influence of visitor presence on lion-tailed macaque behaviour may have been strong enough to supersede the problems of having a small sample size. The combination of the short-term and long-term visitor influence studies provided a comprehensive understanding to the visitor effects on primate behaviour. Recommendations from these studies (refer to Section 9.9 *Conclusions*) could be used to design better exhibits that incorporate visitor barriers into the enclosures for the animals on exhibit. The basic information collected in this study could also provide the preliminary information required to design specific visitor influence studies.

9.4.2. Visitor perception of the zoo

Many Indian visitors to zoos are known to feed and tease captive animals (Venugopal & Sha 1993). In order to address this issue and to gain public support for zoos involved in conservation breeding of the lion-tailed macaque, a visitor perception and awareness study was conducted through a combination of interviews and questionnaires. This questionnaire study (refer to Chapter VI Study 2) showed that a significant proportion of the zoo visiting public claimed that they did not feed or tease the captive animals. Most of the visitors said that they enjoyed their visit to the zoo and that it was a learning experience, since the zoo is the only place they could see several species of animals, especially exotics. Those who saw the lion-tailed macaques at the zoos liked the exhibits because they were large, complex and clean. Many suggested that the lion-tailed macaques looked comfortable in their exhibit. A similar study was conducted on the visitor perception of the gorillas and their exhibit at Belfast Zoo (Blaney & Wells 2004). Overall, their study showed that visitor perception of the gorillas and their exhibit was very positive. The results of visitor perception study suggest that the people visiting Indian zoos enjoyed their visit and liked the lion-tailed macaque exhibit even when the animals on exhibit were displaying behavioural abnormalities. This basically suggests that the visitors could not differentiate between natural and abnormal behaviour patterns. This clearly demonstrates that there is a lack of information made available to the public regarding this species.

This questionnaire study also investigated if the zoo visit had been educational to its visiting public. The study, however, showed that the average zoo visitor knew as much about the biology and behaviour of lion-tailed macaques, protection of its habitat, and rainforest conservation as did the general public (outside the zoo). This clearly suggests that the zoo visit did not educate its visitors about the lion-tailed macaque, its habitat and its conservation. Another study, which showed similar results, was the survey conducted on the awareness and perception (of handed out brochures) of 5000 people living in five cities on the borders of the Nature Reserve of Orange County, California, in USA (Shalene & Crooks 2002). On comparing the awareness between residents to whom Nature Reserve's brochure were handed out with those who had not been given the brochures, it was found that there were very few differences in their respective responses (Shalene & Crooks 2002). In this study, few differences lack between the awareness levels of zoo visitors and the general public (outside the zoo), which suggests that no information is provided at the lion-tailed macaque exhibits in the three study zoos. Alternatively, if information has been provided either on an exhibit label or in the form of an information booklet or leaflet, the information may not be presented in a manner, which would interest the zoo visitors. This implies that further research in label design and presentation of information is needed in order to provide the appropriate information to the visitors, which they could then read and retain.

The visitor perception questionnaire study showed that the three zoos in which the study was conducted did not have an educative influence on their visitors. However, there was a significant difference in the regional awareness levels. People from Thiruvananthapuram were more knowledgeable about issues relating to conservation of the lion-tailed macaque and its habitat, in comparison to people from Chennai and Mysore. There could be two reasons for this; firstly, Thiruvananthapuram is situated in the state of Kerala, which has a 100% literacy rate in comparison to approximately 65% in the states of Karnataka and Tamil Nadu in which the cities of Mysore and Chennai are situated respectively. Also, people living in and around Thiruvananthapuram have a significantly greater chance of seeing lion-tailed macaques in the wild since the species natural habitat is just at a distance of 50 km. Hence, there is a high probability that most visitors to the Thiruvananthapuram Zoo have either seen the lion-tailed macaque in the wild or visited its natural habitat or both.

Assessing zoo education programmes is a challenging task and the use of questionnaires and interviews to assess the educative influence of a zoo is currently being debated (Zoo federation research group, *pers. comm.*). With visitor education being an important goal of the modern zoo, there is an immediate requirement for protocols standardising the methods used to conduct visitor awareness and perception studies in the near future. The American Zoos and Aquaria Association (AZA) spend considerable time in conducting evaluations and research related to visitors' zoo experience (Ogden *et al* 2004). The most efficient method of evaluating the educative influence of a zoo probably would be to conduct questionnaire surveys on visitor perception and awareness along with monitoring education programmes and keeper talks once in six months. The education programmes and keeper talks could be assessed by recording the questions asked by the visitors and also their answers to the questions posed by the zoo educators. Virtual learning tools could also be incorporated on zoo web pages to educate a much wider audience with special sections for school teachers to use in their classes. These virtual education programmes could include a feedback form and a test for varied groups (eg school students, adults, wildlife professionals and teachers).

9.5. REPRODUCTIVE BEHAVIOUR

Monitoring reproductive behaviour becomes crucial for captive primate groups that are part of a breeding programme. For the efficient management of these breeding programmes, it is important to ensure that the populations are healthy and that their welfare is not compromised. An important aim of this study was therefore to investigate the differences in reproductive and social behaviours between breeding and non-breeding individuals. This was done to identify the factors that could influence the lion-tailed macaques' current ability to breed. It must be noted that in the entire Indian captive lion-tailed macaque population, only three males and three females had bred in the past and hence all the results were interpreted from analyses conducted on this small sample size.

Although there were only six proven breeding macaques in the population of 52 Indian captive lion-tailed macaques (refer to Chapter VII), it is clear that proven breeders exhibited significantly lower percentages of abnormal and agonistic behaviours such as bared-teeth face and eye-flash when compared to non-breeding and singly-housed individuals. The non-breeding lion-tailed macaques were mostly animals that had been confiscated from private owners. Rearing history and levels of abnormal behaviours exhibited also appear to be closely linked in these captive individuals (Mallapur in press; see Chapter IV). Early social deprivation (eg Anderson & Chamove 1980, 1985; Chamove *et al* 1984; Mootnick & Baker 1994; Estep & Dewsbury 1996; Mallapur & Choudhury 2003; Mallapur in press) or, even more specifically, the absence of mother-rearing (Hediger 1964; Carlstead 1996) could result in the absence of the specific stimulation required for the normal development of social regulation and complex goal-directed behaviours such as maternal and reproductive behaviours. Even levels of grooming differed significantly between breeding and non-breeding individuals of captive lion-tailed macaques in this study. Individuals with proven breeding history exhibited higher proportions of autogrooming than non-breeding individuals.

Non-breeding lion-tailed macaques in this study spent more time in the part of the enclosure that was closest to the visitor area. They were observed to spend considerable proportions of their time interacting with and directing sexual behaviour towards visitors. The rearing history of these non-breeding (ie confiscated) individuals probably accounts for the time they spent interacting with humans. Zoo visitors are known to influence social and reproductive behaviours exhibited by captive primates (Chamove *et al* 1988; Glatson *et al* 1984). In the visitor influence study conducted on captive lion-tailed macaques (see Chapter VI for visitor influence study), visitor presence influenced both social and reproductive behaviours.

In this study on the reproductive behaviour of captive lion-tailed macaques various factors including; age, early rearing history, percentage of abnormal behaviour exhibited and visitor presence were all found to influence the animal's current ability to breed. This study provides some basic information on the factors that may influence the species ability to breed in captivity, which could be used to identify the types of reproductive and social behaviours influenced by the factors mentioned above and the methods (enrichment or housing) that could be devised to increase levels of natural social and reproductive behaviours exhibited.

Due to the non-invasive nature of this study, health-related issues and physiological problems that might affect an animal's ability to breed were not investigated. Since the study animals (lion-tailed macaques) were part of a breeding programme, strictly 'hands-off' and 'non-invasive' methods of studying the animals had to be such as records of behaviour. Information on the health and physiological problems, if any, would have been useful. As in other international zoos, these details could be collected when the veterinarians conduct their routine checks on the lion-tailed macaques or when these animals are in quarantine or in the zoo hospital. If information on the health and physiological problems of each individual was available, it could have been compared with the behavioural data to check for similarities in breeding success of individuals.

9.6. ASSESSING THE WELFARE OF CAPTIVE LION-TAILED MACAQUES

Assessing the welfare of captive animals forms an integral part of captive animal management (Kirkwood *et al* 2004). Hence, in this study as well, the final aim was to identify variables, which could be used together as a group to assess the welfare of lion-tailed macaques housed in zoos.

More recently, scientists have suggested that welfare is a subjective experience as it related to how an animal feels about its environment. However, animal welfare is not simple to measure (Appleby & Hughes 2000). In order to do so, especially in the zoo environment, a comprehensive method needs to be developed using an assortment of variables as potential welfare indicators (Buchanan-Smith *et al* 2004; Mason & Latham 2004; Prescott & Buchanan-Smith 2004; Webster *et al* 2004). With regard to assessing the welfare and the requirements of captive primates, scientists have strongly encouraged the use of species-specific variables as welfare indicators (Buchanan-Smith *et al* 2004; Prescott & Buchanan-Smith 2004). In this study on the welfare of captive lion-tailed macaques, two groups of variables were found to be most useful for assessing welfare. The 'physical-condition factor' accounted for the highest degree of variance in the data. This factor consisted of variables such as movement, body mass, fur condition and age. Age was inversely related to movement, body mass or fur condition, suggesting, not surprisingly, that animals that were younger moved without difficulty, had a smooth, continuous coat and their muscles were taut. Several other studies have also used physical condition indices to assess the welfare of captive animals (Anderson & Visalberghi 1990; Fraser & Broom 1997; Hughes & Curtis 2000; Webster *et al* 2004). Physical factors such as whether an animal is fat or thin, has poor fur condition, has superficial injuries or is unable to move freely, are very often used as preliminary welfare assessments indicators, especially by veterinarians (Hughes & Curtis 2000; Webster *et al* 2004). These physical factors prove most useful in zoo animal welfare, in which 'non-invasive methods' of assessing welfare are preferred especially in the case of animals that are a part of a breeding programme as in this study. However, the use of physical factors along with other 'non-invasive' measures such as behaviour, rearing history and reproductive success is strongly encouraged. This combination would provide a well-balanced, robust, comprehensive method for assessing the welfare of wild animal in breeding programmes.

For captive lion-tailed macaques, a further factor that could also be used is the 'developmental and reproductive success factor'. This factor consists of the variables – rearing history, current ability to breed, as well as the durations and frequencies of abnormal behaviour performed. This group of variables also accounted for a significant proportion of the total variance in the data from this study on captive lion-tailed macaques. Of the four variables, an individual's current ability to breed was found to be inversely related to rearing history, and durations and frequencies of abnormal behaviour exhibited. This suggested that non-breeding individuals tended to be those that were confiscated and also exhibited higher levels (durations and frequencies) of abnormal behaviours. This coincides with the results of the reproductive behaviour study (see Chapter VII), which suggests that lion-tailed macaques exhibiting higher levels of abnormal behaviour were confiscated and had not bred in the past five years. Behaviour is a commonly used indicator to assess the welfare of animals in captivity (Dawkins 2004; Mason & Latham 2004). Scientists however strongly discourage the use of abnormal behaviour, by itself, to assess the welfare because these behaviours are often exhibited even when the condition in the captive environment has been improved (Mench & Mason 2000; Mason & Latham 2004). As shown in this study on captive lion-tailed macaques, abnormal behaviour can be used along with other inter-related factors such as rearing history and reproductive success (current ability to breed) to assess welfare. Similar combined use of morphometric, physiological, social and behavioural characteristics has been suggested by scientists (Buchanan-Smith *et al* 2004), in order to assess the requirements and welfare of captive primates. Although Buchanan-Smith *et al* (2004) stress on the use of species-specific characteristics, they also encourage the use of variables that take individual variation into account; these include age, sex and individual history. In most welfare assessment studies today, a combination of variables is used as welfare indicators (Haskell *et al* 2003; Hawkins 2003; Horning 2003; Shepherdson *et al* 2004; Webster *et al* 2004). Similar to this study, several assessment studies have used physical condition factors along with behaviour (eg Haskell *et al* 2003; Hawkins 2003; Webster *et al* 2004). In a study on the assessment of pain and suffering in laboratory animals, Hawkins (2003) conducted a questionnaire survey which used simple, commonly used subjective clinical signs to assess welfare. Some of these clinical signs were body weight, behaviour, nasal or oral discharge, physical signs, posture, condition of coat and the animal's general appearance. Haskell *et al* (2003), in their study of welfare assessment of dairy cattle used lameness, physical condition, physical cleanliness and incidence of physical injury to assess the welfare of each individual.

9.7. CONCLUSIONS AND FUTURE WORK

9.7.1. General conclusions

This study on the factors that influence the behaviour and welfare of captive lion-tailed macaques found that certain factors such as abnormal behaviour, rearing history and current ability to breed were strongly interrelated (the developmental and reproductive success factor). Hence, animals that did not breed exhibited high levels of abnormal behaviours and had also been confiscated from private owners. Another group of factors including movement, fur condition, body mass and age were also found to be interrelated. Animals that were old tended to have a sagging musculature, shaggy fur with bald patches and also had difficulty in moving around their enclosures (the physical condition factor). The developmental and reproductive success factor, and the physical condition factor were together found to best explain the behaviour and welfare condition of lion-tailed macaques housed in Indian zoos.

Other factors of the physical environment that influenced the behaviour and welfare of the macaques were enclosure design, group composition, feeding time and visitor presence. By making minor changes with regard to these four factors and by providing a more species-specific environment, this study showed that the welfare of some lion-tailed macaque individuals could be improved significantly. Also, these individuals began to exhibit a more natural behaviour repertoire. Hence, this study has not only managed to standardise welfare indicators for captive lion-tailed macaques, it has also enabled short-term enrichment studies to be designed in order to improve their welfare.

9.7.2. Recommendations for designing a breeding programme for lion-tailed macaques in Indian zoos

In order to create and manage breeding groups so as to establish a successful breeding programme for the lion-tailed macaque in Indian zoos, the staff at each zoo needs to monitor the behaviour of their groups and assess their welfare on a regular basis using the following guidelines listed below (refer to 9.9.1.1).

9.7.2.1. Behavioural monitoring and welfare assessment

1. By recording the behaviour of lion-tailed macaques housed in Indian zoos over a period of two years, several factors influencing the behaviour, welfare and breeding success of these animals could be determined – enclosure design, rearing history and reproductive success.

2. The behaviours exhibited, as well as the welfare and breeding success of an individual, change over time. Hence, to be able to maintain stable breeding groups

consisting of individuals with good welfare and exhibiting a full natural behavioural repertoire, it would be imperative that the reproductive behaviour of all animals in the breeding programme be recorded on a regular basis during the initial stages of the programme.

3. By assessing the welfare of lion-tailed macaques in captivity this study was able to identify factors that influence the welfare of the species and in turn the individual's ability to breed. Hence, periodic assessment of an individual's welfare is also strongly encouraged.

4.Collecting individual information such as age, fur condition, body mass, movement, rearing history, current ability to breed and level of abnormal behaviour exhibited could help zoo staff understand why the animals in their zoo are not breeding.

9.7.2.2. Behaviour and life history factors influencing welfare

The behaviour and life history factors influencing welfare are rearing history, current ability to breed and levels of abnormal behaviour exhibited.

1. Rearing history: This study strongly discourages the use of confiscated males in the breeding programme. These males are not only incapable of breeding at present, but could also potentially harm the females in the group through their excessively aggressive behaviour. For example, Thrissur zoo could have lost one or more females in such male-female encounters. It is also probable that the female at Guindy Childrens Park could have aborted due to interactions with the hyper-aggressive male housed with her.

2. Current ability to breed: By exchanging males with other zoos and introducing males with proven breeding history to the females, the group's chances of breeding could possibly be improved (as, for example, in Trivandrum, Patna and Mysore Zoos whose group consist only of confiscated males). Age was also found to influence breeding. Younger animals should be included in groups consisting of old females

(as, for example, in Delhi, Mysore and Nandankanan Zoos whose females are mostly > 18 years of age).

3. Exhibition of abnormal behaviours: By providing a naturalistic environment and through the provision of environmental enrichment, stress levels in zoo-born animals could be reduced. With confiscated animals, however, abnormal behaviours currently exhibited may have been retained from past poor conditions. Further research would be required to design appropriate housing for such confiscated individuals.

9.7.2.3. Body condition factors influencing welfare

1. Movement, fur condition and body mass: by assessing the welfare of individuals using these indicators, zoo staff can try and improve the welfare of individual animals by targeting the factors affecting them. For example, animals having poor fur condition would require special skin care or individuals who are fat or have a sagging musculature would need a revision in their diets and enclosure design to get the individuals to work for their food. A variety of food presentation techniques can be used to make feeding unpredictable. Scatter feeding for example, to result in getting the animals to exhibit higher levels of foraging and exploratory behaviours as well as to increase their movement patterns around the enclosure.

2. Age: Animals that are old and have difficulty in moving around their enclosures would also have special requirements. Care should be taken to make it easier for them to access food and shelter. If housed in a group, it would probably be better to feed them separately due to competition with younger and dominant animals in the group for food resources.

9.7.2.4. Physical factors influencing behaviour and welfare

1. Enclosure design: enclosure design was found to influence the behaviour of captive lion-tailed macaques. Animals should be housed in naturalistic enclosures that have a mud, soil or sand flooring, trees or bushes, water body

or water tank in their enclosure. A complex environment such as this will provide them with the appropriate environment to exhibit a more natural behavioural repertoire.

2. Group composition: lion-tailed macaques live in complex multi-female groups in the wild. Housing them singly or in pairs could adversely influence their behaviour and welfare. Along with being housed in a complex enclosure, this study strongly encourages zoos to house their lion-tailed macaques in social groups of more than two animals, but with an appropriate male-female ratio for more than two females with young along with one male.

3. Visitor presence: visitors were found to have a detrimental influence on the behaviour and welfare of lion-tailed macaques in captivity. Reproductive behaviours in particular were adversely influenced by visitor presence. Zoo staff is encouraged to consider the option of housing breeding groups off-exhibit. However, if this is not possible, the lion-tailed macaque enclosure should offer the animals with an opportunity to climb in order to maintain a distance from the zoo visitor. The enclosure should also include hide-outs and visitor barriers in certain areas of the enclosure to give the macaques an option of hiding from the public. In addition, the zoo management should consider taking stern action against noisy and abusive zoo visitors as their actions are likely to adversely influence the behaviour, reproductive success and welfare of lion-tailed macaques.

4. Off-exhibit enclosures for breeding groups: in order to provide optimal housing for the breeding groups, it is strongly encouraged that these groups are provided with off-exhibit housing. This will not only reduce visitor pressure on the breeding groups, it will also provide the surplus lion-tailed macaques (previously housed in small cages) with a larger on-exhibit enclosure (old enclosure of the breeding group) to be displayed in.

9.7.3. The significance of this welfare study to the lion-tailed macaque breeding programme in India

At present, there is no information on the behaviour and welfare of the entire captive Indian lion-tailed macaque population. There are also no standardised guidelines or protocols for the husbandry and management practices for maintaining these macaques in Indian zoos. Of the 18 Indian zoos that house this species, the lion-tailed macaque is breeding in only one. In order to explain their inability to breed and to devise methods to improve their breeding success, it would be imperative to study the behaviour and welfare of each macaque individual in the captive Indian population. This study has not only managed to document the behavioural and welfare problems of this species in detail, but has also identified the factors that influence the current ability of specific individuals to breed. Implementation of the recommendations from this study could lead to better husbandry and management practice with regard to maintaining the lion-tailed macaque in Indian zoos. The ethogram, behaviour and welfare aspects of this study would also provide the basic and applied behavioural monitoring required in establishing a successful breeding programme for this species in India.

References

Allen M E and Oftedal O T 1996 Essential nutrients in mammalian diets. In: Kleiman D G, Allen M G, Thompson K V and Lumpkin S (Eds) *Wild Mammals in Captivity: Principles and Techniques.* pp 117-128 University of Chicago Press: Chicago, USA

Anderson J R and Chamove A S 1980 Self–aggression and social aggression in laboratory–reared macaques. *Journal of Abnormal Psychology 89*: 539-550

Anderson J R and Chamove A S 1985 Early social experience and the development of self-aggression in monkeys. *Biology of Behaviour 10*: 147-157

Anderson J R and Visalberghi E 1990 Primate psychological well-being: A comparative approach to environmental enrichment for captive primates. In *Society for Veterinary Ethology Summer Meeting* 1990 Proceedings. Montecatini Terme: Pistoia, Italy 59-61

Anderson U S, Benne M, Bloomsmith M and Maple T 2002 Retreat space and human visitor density moderate undesirable behavior in petting zoo animals. *Journal of Applied Animal Welfare Science 5*: 125-137

Anonymous 1993 Lion tail macaque *Macaca silenus* population and habitat viability assessment workshop report: Madras. *Zoos' Print 8*: 11-23

Anonymous 1996 Small population biology and the tools of recovery: A training workshop using lion-tailed macaque as a case study. *Zoos' Print 11*: 23-26

Appleby M C and Hughes B O 2000 *Animal Welfare.* CAB International: Oxford, UK

Appleby M C and Waran N K 2000 Physical conditions. In: Appleby M C and Hughes B O (Eds) *Animal Welfare* pp 177-190. CAB International: Oxford, UK

Aveling R J 1987 Environmental education in developing countries. In: Marsh C W and Mittermeier R A (Eds) *Primate Conservation in the Tropical Rain Forest.* pp 231-262 Alan R. Liss: New York, USA

Baldwin C F 1985 *Behavior of Carnivores in Outdoor Exhibits at the National Zoological Park* PhD Dissertation, George Mason University, Virginia

Beck B 1997 Reintroduction, zoos, conservation, and animal welfare. In: Norton B G, Hutchins M, Stevens E F and Maple T L (Eds) *Ethics of the Ark: Zoos,* *Animal Welfare, and Wildlife Conservation.* pp 155-163 Smithsonian Institute Press: Washington DC, USA

Birke L 2002 Effects of browse, human visitors and noise on the behaviour of captive orang-utans. *Animal Welfare 11*: 189 - 202

Blaney E C and Wells D L 2004 The influence of a camouflage net barrier on the behaviour, welfare and public perceptions of zoo-housed gorillas. *Animal Welfare 13*: 111-118

Bloomsmith M A, Alford P L and Maple T L 1988 Successful feeding enrichment for captive chimpanzees. *American Journal of Primatology 16*: 155-164

Bloomsmith M A and Lambeth S P 1995 Effects of predictable versus unpredictable feeding schedules on chimpanzee behavior. Applied Animal Behaviour Science 44: 65-74

Brambell F W R 1965 The report of the technical committee to enquire into the welfare of animals kept under intensive livestock husbandry systems. HMSO Command Report: London, UK

Broom D M 1986 Indicators of poor welfare. *British Veterinary Journal 142*: 524-526

Buchanan-Smith H M 1995 Effect of food distribution on captive old world primates. *Shape of Enrichment 4*: 12-13

Buchanan-Smith H M 1996 Enriching the lives of marmosets and tamarins in captivity. *Shape of Enrichment 5*: 3-5

Buchanan-Smith H M 1997 Environmental control: an important feature of good captive callithrichid environments. In: Pryce C, Scott L and Schnell C (Eds) *Marmosets and Tamarins in Biological and Biomedical Research.* pp 47-53 DSSD Imagery: Salisbury, UK

Buchanan-Smith H M, Prescott M J and Cross N J 2004 What factors should determine cage sizes for primates in the laboratory? *Animal Welfare Supplement 13*: S197-S202

Caras R 1995 Zoos and the public A view from the ASPCA In: Norton B G, Hutchins M, Stevens E F, Maple T L (Eds) *Ethics on the Ark.* pp 297-300 Smithsonian Institution Press: Washington DC, USA

Carlstead K 1996 Effects of captivity on the behaviour of wild mammals. In: Kleiman D G, Allen M G, Thompson K V, Lumpkin S, (Eds). *Wild Mammals in Captivity: Principles and Techniques*. pp 317-333 University of Chicago Press: Chicago, USA

Carlstead K 1998 Determining the causes of stereotypic behaviour in zoo carnivores: Towards developing appropriate enrichment. In: Shepherdson D J, Mellen J and Hutchins M (Eds) *Environmental Enrichment for Captive Animals*. pp 172-183 Smithsonian Institute Press: Washington DC, USA

Carlstead K and Shepherdson D 1994 Effects of environmental enrichment on reproduction. *Zoo Biology 13*: 447-458

Cattell R B, Blaine D D and Brennan J M 1984 *N*-way factor analysis for obtaining personality-environment-test contribution systems to any response: A plasmode illustration. In: Law H G, Snyder C W Jr, Hattie J A and McDonald R P (Eds) *Research Methods for Multimode Data Analysis.* pp 333-370 Praeger: New York, USA

Chamove A S and Anderson J R 1981 Self-aggression, stereotypy and self-injurious behaviour in man and monkeys. *Current Psychological Reviews 1*: 245-255

Chamove A S, Anderson J R and Nash V J 1984 Social and environmental influences on self-aggression in monkeys. *Primates 25*: 319-325

Chamove A S, Hosey G R and Schaetzel P 1988 Visitors excite primates in zoos. *Zoo Biology 7*: 359-369

Clarke A S, Harvey N C and Lindburg D G 1993 Extended postpregnancy estrous cycles in female lion-tailed macaques. *American Journal of Primatology 31*: 275-285

Clarke A S, Juno C J and Maple T L 1982 Behavioural effects of a change in the physical environment: a pilot study of captive chimpanzees. *Zoo Biology 1*: 371-380

Clubb R and Mason G 2002 *A Review of the Welfare of Elephants in European Zoos*. Royal Society for the Prevention of Cruelty to Animals: Horsham, UK

Clutton-Brock T H and Harvey P H 1980 Primates, brains and ecology. *Journal of Zoology 190*: 309-323

Cook S and Hosey G R 1995 Interaction sequences between chimpanzees and human visitors at the zoo *Zoo Biology 14*: 431-440

Cowlishaw G and Dunbar R 2000 *Primate Conservation Biology.* Univesity of Chicago Press: Chicago, USA 498p

Cox C R 1997 Drills (*Mandrillus leucopaeus*): research and conservation initiatives, 1986 - 1996. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks.* pp 151-176 American Society of Primatology: Oregon, USA

Dawkins M S 2004 Using behaviour to measure animal welfare. *Animal Welfare 13*: S3-7

DETR 2000 *Secretary of State's Standards for Modern Zoo Practice.* 156p

de Vries T 2003 Animal and human behaviour, genes and environment in comparative ethology of primates. *Revista de la Pontificia Universidad Catolica Del Ecuador 71*: 217-223

dos Santos E, Leme S C and Pessutti C 1997 Golden-handed tamarin *Saguinus midas midas*, ethogram. *Advances in Ethology 32*: 296 [Abstract]

Duncan I J H and Fraser D 2000 Understanding animal welfare. In: Appleby M C and Hughes B O (Eds) *Animal Welfare.* pp 19-32 CAB International: Oxon, UK

Durrell G 1960 *A Zoo in My Luggage.* Penguin Publishers: London, UK

Durrell G and Mallinson J 1987 Reintroduction as a political and educational tool for conservation. *DODO (Journal of Durrell Wildlife Conservation Trust) 24*:6-19

Dytham C 1999 *Choosing and Using Statistics - a Biologist's Guide.* Blackwell Science: Oxford, UK

Elton R H 1979 Baboon behavior under crowded conditions In: Maple T L, Erwin J and Mitchell G (Eds) *Captivity and Behavior: Primates in Breeding Colonies, Laboratories and Zoos.* pp 125-138 Van Nostrand Reinhold: New York, USA

Erwin J and Deni R 1979 Strangers in a strange land: abnormal behaviors or abnormal environments? In: Maple T L, Erwin J and Mitchell G (Eds) *Captivity and Behavior: Primates in Breeding Colonies, Laboratories and Zoos.* pp 1-28 Van Nostrand Reinhold: New York, USA

Erwin J 1979 Aggression in captive macaques: Interaction of social and spatial factors In: Maple T L, Erwin J and Mitchell G (Eds) *Captivity and Behavior: Primates in Breeding Colonies, Laboratories and Zoos*. pp 139-171 Van Nostrand Reinhold: New York, USA

Estep D Q and Baker S C 1991 The effects of temporary cover on the behavior of socially housed stumptailed macaques (*Macaca arctoides*). *Zoo Biology 10*: 465-472

Estep D Q and Dewsbury D A 1996 Mammalian reproductive behaviour. In: Kleiman D G, Allen M G, Thompson K V, Lumpkin S (Eds) *Wild Mammals in Captivity: Principles and Techniques.* pp 379-389 University of Chicago Press: Chicago, USA

Fa J E and Lindburg D G 1996 *Evolution and Ecology of Macaque Societies* (Eds) Cambridge University Press: New York, USA 597p

Foose T J and Conway M 1985 Models of population management of Lion-tailed macaques resources in captivity. In: Heltne P G (Ed) *The Lion-tailed Macaque: Status and Conservation.* pp 329-342 Alan R Liss: New York, USA

Fossey D 1983 *Gorillas In The Mist.* Houghton Mifflin Company: Boston, USA

Fraser A F and Broom D M 1997 *Farm Animal Behaviour and Welfare.* CAB International: London, UK

Fraser D and Matthews L R 2000 Preference and motivation testing. In: Appleby M C and Hughes B O (Eds) *Animal Welfare.* pp 159-174 CAB International: Oxon, UK

Fritz J, Nash L T, Alford P L and Bowen J A 1992 Abnormal behaviors, with a special focus on rocking, and reproductive competence in a large sample of captive chimpanzees (*Pan troglodytes*). *American Journal of Primatology 27*: 161-176

Fuentes A and Wolfe LD 2002 *Primates Face To Face: Conservation Implications Of Human-Nonhuman Primate Interconnections*. Cambridge University Press: New York, USA

Glatston A R, Soeteman E G, Pecek E H, Hooff J A R A M V 1984 The influence of the zoo environment on social behaviour of groups of cotton-topped tamarins, *Saguinus oedipus oedipus. Zoo Biology 3*: 241-253

Gledhill L and Walker S 1996 Small population biology and the tools of recovery: *Ex situ* report. *Zoos' Print 11*: 27

Goerke B, Fleming L and Creel M 1987 Behavioural changes of a juvenile gorilla after a transfer to a more naturalistic environment. *Zoo Biology 6*: 283-295

Gold K C 1997 The conservation role of primate exhibits in the zoo In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 43-62 American Society of Primatology: Oregon, USA

Goodall J 1971 *In The Shadow Of Man*. Houghton Mifflin Company: New York, USA

Green S and Minkowski K 1977 The lion-tailed macaque in its Southern Indian Rainforest habitat. In: Rainier H S H III and Bourne G H (Eds) *Primate Conservation*. pp 290-338 Alan Liss Inc: New York, USA

Gupta A K 2001 Non-human primates of India: An introduction. In Gupta A K (Ed) *ENVIS Bulletin: Wildlife and Protected Areas, Non-Human Primates of India 1*: 1–29

Hanson E 2002 *Animal Attractions: Nature on Display in American Zoos*. Princeton University Press: Princeton, USA

Harcourt A H 1996 Is the gorilla a threatened species? How should we judge? *Biological Conservation 75*: 165-176

Harvey N C and Lindburg D G 1992 Affiliative and sexual behavior during the menstrual cycle and pregnancy in group living lion-tailed macaques (*Macaca silenus*). *American Journal of Primatology 27*: 33 (Abstract)

Harvey N C and Lindburg D G 2001 A long-term decline in swelling of the sexual skin in captive long-tailed macaques. *Primate Report 59*: 43-49

Harvey N C, Clarke A S and Lindburg D G 1991 Reproductive synchrony in captive female lion-tailed macaques. *American Journal of Primatology 24*: 107 (Abstract)

Harvey N C, Clarke A S, Czekala N M and Kedenburg H D 1990 Characteristics of postpartum cycles in lactating female lion-tailed macaques (*Macaca silenus*). *American Journal of Primatology 20*: 196-197

Harvey N C, De Falco K M and Lindburg D G 1995 Social/agonistic behavior and copulation patterns in male lion-tailed macaques (*Macaca silenus*) housed in a heterosexual captive group *American Journal of Primatology 36*: 127 (Abstract)

Harvey N C, De Falco K M and Lindburg D G 2001 Effects of female swelling stage and male vasectomy on male/female interactions in colony living lion-tailed macaques. *American Journal of Primatology 54*: 38 (Abstract)

Harvey N C, De Falco K M, Vasseaur D and Lindburg D G 1998 Changes in female swelling patterns and rate of male copulation during the follicular phase in group living lion-tailed macaques (*Macaca silenus*): Effects of vasectomy, female age, or partner boredom? *American Journal of Primatology 45*: 184 (Abstract)

Haskell M J, Rennie L J, Bowell V A, Wemelsfelder F and Lawrence A B 2003 On-farm assessment of the effect of management and housing type on behaviour and welfare of dairy cattle. *Animal Welfare 12*: 553-556

Hawkings P 2003 Assessing pain, suffering and distress in laboratory animals: an RSPCA survey of current practice in the UK. *Animal Welfare 12*: 517-522

Hearn G W, Weikel E C and Schaaf C D 1986 A preliminary ethogram and study of social behavior in captive drills, *Mandrillus leucophaeus*. *Primate Report 14*: 72 [Abstract]

Hearn G W, Weikel E C and Schaaf C D 1988 A preliminary ethogram and study of social behavior in captive drills, *Mandrillus leucophaeus*. *Primate Report 19*: 11-17

Hebert P L and Bard K 2000 Orangutans use of vertical space in an innovative habitat. *Zoo Biology 19*: 239-251

Hediger H 1964 *Wild Animals in Captivity*. Dover Publications: New York, USA

Heistermann M, Uhrigshardt J, Husung A, Kaumanns W and Hodges J K 2001 Measurement of faecal steroid metabolites in the lion-tailed macaque

(*Macaca silenus*): A non-invasive tool for assessing female ovarian function. *Primate Report 59*: 27-39

Horning B 2003 Attempts to integrate different parameters into an overall picture of animal welfare using investigations in dairy loose houses as an example. *Animal Welfare 12*: 557-564

Hosey G R 2000 Zoo animals and their human audiences: What is the visitor effect? *Animal Welfare 9*: 343-357

Hosey G R and Druck P L 1987 The influence of zoo visitors on the behaviour of captive primates. *Applied Animal Behaviour Science 18*: 19-29

Hosey G R, Jacques M and Burton M 1999 Allowing captive marmosets to choose the size and position of their nest box. *Animal Welfare 8*: 281-285

Hughes B O and Curtis P E 2000 Health and disease. In: Appleby M C and Hughes B O (Eds) *Animal Welfare.* pp 109-126 CAB International: Oxon, UK

Hutchins M, Dresser B and Wemmer C 1995 Ethical considerations in zoos and aquarium research. In: Norton B G, Hutchins M, Stevens E F and Maple T L (Eds) *Ethics of the Ark: Zoos, Animal Welfare, and Wildlife Conservation.* pp 253-276 Smithsonian Institute Press: Washington DC, USA

Ings R, Waran N K and Young R 1997 Attitude of zoo visitors to the idea of feeding live prey to zoo animals *Zoo Biology 16*: 343 - 347

IUDZG/ CBSG (IUCN/ SSC) 1993 *The World Zoo Conservation Strategy: The Role Of The Zoos And Aquaria Of The World In Global Conservation.* pp 26-33 Chicago Zoological Society: Chicago, USA

Jamieson D 1995 Wildlife conservation and individual animal welfare. In: Norton B G, Hutchins M, Stevens E F and Maple T L (Eds) *Ethics on the Ark.* pp 69-73 Smithsonian Institution Press: Washington DC, USA

Johnson P C 1985 Notes on the ethogram of captive lion-tailed macaques. In: Heltne P G (Eds) *The Lion-Tailed Macaque: Status And Conservation* pp 239-263. Liss: New York, USA

Johnson L D, Petto A J and Sehgal P K 1991 Survival and reproduction as measures of psychological well-being in Cotton-Top Tamarins. In: Novak M A and Petto A J (Eds) *Through the Looking Glass: Issues of Psychological Well-*

being in Captive Non-human Primates. pp 93-102 American Psychological Association: Washington DC, USA

Jolly C J and King A W 1985 Serogenetic analysis and the conservation of lion-tailed macaques. In: Heltne P G (Ed) *The Lion-tailed Macaque: Status and Conservation*. pp 195-219 Alan R Liss: New York, USA

Judge P G and de Waal F B M 1997 Rhesus monkey behaviour under diverse population densities: Coping with long-term crowding. *Animal Behaviour 54*: 643-662

Karanth K U 1992 Conservation prospects for lion-tailed macaques in Karnataka, India. *Zoo Biology 11*: 33-41

Kaumanns W and Rohrhuber B 1995 Captive propagation in lion-tailed macaques: Status of the European population and research implications. In Ganslober U, Hodges J K and Kaumanns W (Eds). *Research and Captive Propagation*. pp 296-309 Fürth: Filander Verlag, Germany

Kaumanns W, Schmid P, Schwitzer C, Husung A and Snogge C 2001 The European population of lion-tailed macaques (*Macaca silenus*): status and problems. *Primate Report 59*: 65-75

Kessel A L and Brent L 1996 Space utilization by captive-born baboons (*Papio* spp.) before and after provision of structural enrichment. *Animal Welfare 5*: 37-44

Kiley-Worthington M 1977 *Behavioral Problems of Farm Animals*. pp 153 Oriel Press: Stockfield, UK

Kirkwood J K, Roberts E A and Vickery S 2004 *Science in the Service of Animal Welfare. Proceedings of the UFAW International Symposium*. Edinburgh: UFAW

Kleiman D G and Mallinson J J C 1998 Recovery and management committees for lion tamarins: partnership in conservation planning and implementation. *Conservation Biology 12*: 27-38

Kleiman D G, Beck B B, Dietz J M and Dietz L A 1991 Costs of re-introduction and criteria for success: accounting and accountability in the Golden Lion Tamarin Conservation Program. *Symposium of the Zoological Society of London 62*: 125-142

Kleiman D G, Beck B B, Dietz J M, Dietz L A, Ballou J D and Coribra-Filho A F 1986 Conservation program for the golden lion tamarin: captive research and management, ecological studies, educational strategies and reintroduction. In: Benischke K (Ed) *Primates: The Road to Self-Sustaining Populations.* pp 959-979 Springer Verlag: New York, USA

Koontz F W 1997 Zoos and in situ primate conservation In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks.* pp 63-82 American Society of Primatology: Oregon, USA

Kratochvil H and Schwammer H 1997 Reducing acoustic disturbances by aquarium visitors. *Zoo Biology 16*: 349 - 353

Kumar A 1987 *The Ecology and Population Dynamics of the Lion-tailed Macaque,* Macaca silenus in *South India.* PhD thesis, Cambridge University: Cambridge, UK

Kumar A 1990 The third international symposium on the lion-tailed macaque. *Zoos' Print* 22-23

Kumar A 1995 The life history, ecology, distribution and conservation problems in the wild. In: Kumar A, Molur S and Walker S (Eds) *The Lion-Tailed Macaque: Population and Habitat Viability Assessment Workshop.* pp 7-17 Zoo Outreach Organisation: Coimbatore, India

Kumar A 1997 Life history parameters of the lion-tailed macaque, *Macaca silenus*: a comparison of wild and captive populations. *Zoos' Print 12*: 31-35

Kumar A 2001 Mounting pattern in the lion-tailed macaque: an analysis based on inter-mount intervals. *Primate Report 59*: 19-26

Kumara H N, Singh M E, Sharma A K, Singh M R and Kumar A M 2000 Faunal component in the diet of lion-tailed macaque. *Primate Report 58*: 57-65

Lacy R, Ballou J and Molur S 1996 Small population biology and the tools of recovery: in situ report. *Zoos' Print 11*: 9-23

Lehner P N 1996 *Handbook of Ethological Methods.* pp 183-232 Cambridge University Press: Cambridge, UK

Lindburg D G 1990 Proceptive calling by female lion-tailed macaques. *Zoo Biology 9*: 437-446

Lindburg D G 2001 A century of involvement with lion-tailed macaques in North America. *Primate Report 59*: 51-64

Lindburg D G and Gledhill L G 1992 Captive breeding conservation of the lion-tailed macaques. *Endangered Species Update 10*: 1-4

Lindburg D G and Harvey N C 1996 Reproductive biology of captive lion-tailed macaques. In: Fa J E and Lindburg D G (Eds) *Evolution and Ecology of Macaque Societies*. pp 318-341 Cambridge University Press: Cambridge, UK

Lindburg D G, Iaderosa J and Gledhill L 1997 Steady-state propagation of captive lion-tailed macaques in North American zoos: a conservation strategy. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 131-149 American Society of Primatology: Oregon, USA

Lindburg D G, Lyles A M and Czekala N M 1989 Status and reproductive potential of lion-tailed macaques in captivity. *Zoo Biology Supplement 1*: 5-16

Little K A and Sommer V 2002 Change of enclosure in langur monkeys: implications for the evaluation of environmental enrichment. *Zoo Biology 21*: 549-559

Lofton R 1995 Captive breeding of endangered species. In: Norton B G, Hutchins M, Stevens E F and Maple T L (Eds) *Ethics of the Ark: Zoos, Animal Welfare, and Wildlife Conservation*. pp 164-180 Smithsonian Institute Press: Washington DC, USA

Ludes E and Anderson J R 1996 Comparison of the behaviour of captive white-faced capuchin monkeys (*Cebus capucinus*) in the presence of four kinds of deep litter. *Journal of Applied Animal Behaviour Science 49*: 293-303

Ludes-Fraulob E and Anderson J R 1999 Behaviour and preferences among deep litters in captive capuchins monkeys (*Cebus capucinus*) *Animal Welfare 8*: 127-134

Lukas K E 1999 A review of nutritional and motivational factors contributing to the performance of regurgitation and reingestion in captive lowland gorillas (*Gorilla gorilla gorilla*). *Applied Animal Behaviour Science 63*: 237-249

Lukas K E, Barkauskas R T, Maher S A, Jacobs B A, Bauman J E, Henderson A J and Calcagno J M 2002 Longitudinal study of delayed reproductive success in a pair of white-cheeked gibbons (*Hylobates leucogenys*). *Zoo Biology 21*: 413-434

Lukas K E, Hamor G, Bloomsmith M A, Horton C L and Maple T L 1999 Removing milk from captive gorilla diets: The impact on regurgitation and reingestion (R/R) and other behaviors. *Zoo Biology 18*: 515-528

Macedonia J M 1987 Effects of housing differences upon activity budgets in captive sifakas (*Propithecus verreauxi*). *Zoo Biology 6*: 55-67

Mallapur A and Ravi Chellam 2002 Environmental influences on the activity budget of leopards (*Panthera pardus*) in four zoos in southern India *Zoo Biology 21*: 585- 595

Mallapur A and Choudhury B C 2003 Behavioral abnormalities in captive non-human primates *Journal of Applied Animal Welfare Sciences 6*: 275-284

Mallapur A in press Managing primates in zoos: Lessons from animal behaviour. *Current Science*

Mallapur A, Waran N & Sinha A in press Factors Influencing the Behaviour & Welfare of Captive Lion-tailed Macaques (*Macaca silenus*) housed in Indian Zoos *Applied Animal Behaviour Science*

Mallapur A, Qureshi Q and Ravi Chellam 2002 Influences of enclosure design on the utilisation of space by leopards (*Panthera pardus*) in four zoos in southern India. *Journal of Applied Animal Welfare Sciences 5*: 111-124

Mallinson J J C, Smith J D, Darwent M and Carroll J B 1994 The design of the Sumatran orang-utan *Pongo pygmaeus abelii* 'home-habitat' at the Jersey Wildlife Preservation Trust. *DODO Journal of Durrell Wildlife Conservation Trust 30*: 15-32

Malone N 1998 Providing orangutans with opportunities for arboreal behaviour. *Shape of Enrichment 7*: 1-2

Maple T and Perkins L 1996 Enclosure furnishings and structural environmental enrichment. In: Kleiman D G, Allen M G, Thompson K V, Lumpkin S (Eds) *Wild Mammals in Captivity: Principles and Techniques*. pp 212-222 University of Chicago Press: Chicago, USA

Maple T L 1979 Great apes in captivity: The good, the bad, and the ugly. In: Maple T L, Erwin J and Mitchell G (Eds) *Captivity and Behavior: Primates in*

Breeding Colonies, Laboratories and Zoos. pp 239-272 Van Nostrand Reinhold: New York, USA

Maple T, Mcmanamon R and Stevens E 1995 Defining the good zoo: animal care, maintenance and welfare. In: Norton B G, Hutchins M, Stevens E F, Maple T L (Eds) *Ethics on the Ark*. pp 219-234 Smithsonian Institution Press: Washington, USA

Margulis S W, Hoyos C and Anderson M 2003 Effect of felid activity of zoo visitor interest. *Zoo Biology 22*: 587-599

Marriner L M and Drickamer L C 1994 Factors influencing stereotyped behaviour of primates in a zoo. *Zoo Biology 13*: 267-275

Martinic G 1990 A short report on the construction of an ethogram from observations made on four *Macaca fascicularis* monkeys. *Animal Technology 41*: 217-222

Martin P and Bateson P 1994 *Measuring Behaviour*. Cambridge University Press: Cambridge, UK

Mason G J 1991 Stereotypies: A critical review. *Animal Behaviour 41*: 1015-1037

Mason G J and Latham N R 2004 Can't stop, won't stop: is stereotypy a reliable animal welfare indicator? *Animal Welfare Supplement 13*: S57-S70

McPhee M E, Foster J S, Sevenich M and Saunders C D 1998 Public perceptions of behavioural enrichment: Assumptions gone awry. *Zoo Biology 17*: 525 - 534

Mellen J 1992 Effects of early experience on subsequent adult sexual behaviour using domestic cats (*Felis catus*) as a model for exotic small felids *Zoo Biology* 11:17-32

Mench J A and Mason G J 2000 Behaviour. In: Appleby M C and Hughes B O (Eds) *Animal Welfare*. pp 127-142 CAB International: Oxford, UK

Mitchell G, Obradovich S D, Herring F H, Dowd B and Tromborg C 1991 Threats to observers, keepers, visitors and others by zoo mangabeys (*Cercocebus galeritus chrysogaster*). *Primates 32*: 515-522

Mitchell G, Seteriou S, Towers S, Kenney L and Schumer C 1987 Descriptive accounts of the behavior of breeding and nonbreeding pairs of golden-bellied mangabeys (*Cercocebus galeritus chrysogaster*). *Zoo Biology 6*: 391-399

Mittermeier R A 1997 Foreword. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks.* pp xi-xiii American Society of Primatology: Oregon, USA

Mootnick A R and Baker E 1994 Masturbation in captive *Hylobates* (gibbons). *Zoo Biology 13*: 345-353

Morin P A and Ryder O A 1991 Founder contribution and pedigree inference in a captive breeding colony of lion-tailed macaques using mitochondrial DNA and DNA fingerprint analysis. *Zoo Biology 10*: 341-352

Nameer P O, Molur S and Walker S 2001 Mammals of the Western Ghats: A simplistic overview. *Zoos' Print 16*: 629-639

Neveu H and Deputte B L 1996 Influence of availability of perches on the behavioral well-being of captive, group-living mangabeys. *American Journal of Primatology 38*: 175-185

Newberry R C 1995 Environmental enrichment: Increasing the biological relevance of captive environments. *Applied Animal Behaviour Science 44*: 229-243

Nickelson S A and Lockard J S 1978 Ethogram of Celebes monkeys (*Macaca nigra*) in two captive habitats. *Primates 19*: 437-447

O'Neill P L, Novak M A and Suomi S J 1991 Normalizing laboratory-reared rhesus macaque (*Macaca mulatta*) behavior with exposure to complex outdoor enclosures. *Zoo Biology 10*: 237-245

Oftedal O T and Allen A E 1996 The feeding and nutrition of omnivores with emphasis on primates. In: Kleiman D G, Allen M G, Thompson K V, Lumpkin S (Eds) *Wild Mammals in Captivity: Principles and Techniques*. pp 148-157 University of Chicago Press: Chicago, USA

Ogden J, Gentle C and Revard A 2004 Conservation education: A primer. *Communique* 19-20

Petherick J C and Rushen J 2000 Behavioural restriction. In: Appleby M C and Hughes B O (Eds) *Animal Welfare.* pp 89-106 CAB International: Oxon, UK

Prescott M J and Buchanan-Smith H M 2004 Cage sizes for tamarins in the laboratory. *Animal Welfare 13*: 151-158

Primack R B 1993 *Essentials of Conservation Biology.* Sinauer Associates: Sunderland, USA

Rabin L A 2003 Maintaining behavioural diversity in captivity for conservation: Natural behaviour management. *Animal Welfare 12*: 85-94

Raghavan R 2001 Social behaviour and communication among wild lion-tailed macaque (*Macaca silenus*) in the Indira Gandhi Wildlife Sanctuary, Tamil Nadu. MSc Dissertation, Saurashtra University: Rajkot, India

Ramachandran K K and Joseph G K 2000 Habitat utilization of lion-tailed macaque (*Macaca silenus*) in Silent Valley National Park, Kerala, India. *Primate Report 58*: 17-25

Redshaw M J and Mallison J J C 1991 Learning from the wild: Improving the psychological and physical well-being of captive primates. *DODO (Journal of Durrell Wildlife Conservation Trust) 27*: 18-26

Reinhardt V 1993 Promoting increased foraging behaviour on caged stump-tailed macaques. *Folia Primaologica 61*: 47-51

Reinhardt V 1997 Refining the traditional housing and handling of research macaques. Monograph online available at http://pantheon.yale.edu/~seelig/pef /new/new.html 9p

Reinhardt V and Roberts A 1996 Effective feeding enrichment for non-human primates: a brief review. *Animal Welfare 6:* 265-272

Reinhardt V, Houser W D, Eisele S G and Champoux M 1987 Social enrichment of the environment with infants for singly caged adult rhesus monkeys. *Zoo Biology 6*: 365-371

Reinhardt V, Liss C and Stevens C 1995 Social housing of previously single-caged macaques: what are the options and the risks? *Animal Welfare 4*: 307-328

Reinhardt V, Liss C and Stevens C 1996 Comparing cage space requirements for nonhuman primates in the United States and in Europe. *Animal Welfare Information Center Newsletter 7*: 12-13

Rendall D and Taylor L L 1991 Female sexual behaviour in the absence of male-male competition in captive Japanese macaques (*Macaca fuscata*). *Zoo Biology 10*: 319-328

Savage A, Giraldo H and Soto L 1997 Developing a conservation action program for the cotton-top tamarin (*Saguinus oedipus*). In: Wallis J (Ed) *Primate*

Conservation: The Role of Zoological Parks. pp 97-111 American Society of Primatology: Oregon, USA

Selye H 1950 *The Stress of Life.* McGraw Hill Book Company: New York, USA

Shalene G and Crooks K 2002 Attitudes, knowledge, and education of residents living on the urban-wildland interface Society of Conservation Biology 16th Annual Meeting co-hosted by DICE and the British Ecological Society p 18. Kent, UK

Shapiro S J, Porter L M, Suarez S A and Bloomsmith M A 1995 Behaviour of singly –caged yearling rhesus monkeys is affected by the environment outside the cage. *Journal of Applied Animal Behaviour Sciences 45:* 151-163

Shepherdson D J 1998 Introduction: tracing the path of environmental enrichment in zoos. In: Shepherdson D J, Mellen J and Hutchins M (Eds) *Second Nature: Environmental Enrichment for Captive Animals* pp 1-12. Smithsonian Institution Press: Washington, USA

Shepherdson D J, Carlstead K C and Wielebnowski N 2004 Cross-institutional assessment of stress responses in zoo animals using longitudinal monitoring of faecal corticoids and behaviour. *Animal Welfare Supplement 13*: S105-S114

Siegal S and Castellan N J 1988 *Nonparametric Statistics for the Behavioural Sciences* McGraw-Hill: New York, USA

Simpson J A and Weiner E S 1998 *Oxford Compact English Dictionary.* Oxford University Press: Oxford, UK 253p

Singh M, Kumara H N, Ananda Kumar M, Sharma A K and De Falco K 2000 Status and conservation of lion-tailed macaque and other arboreal mammals in tropical rainforests of Sringeri forest range, Western Ghats, Karnataka, India. *Primate Report 58*: 5 – 16

Singh M, Singh M, Kumara H N, Ananda Kumar M and D'Souza L 1997 Inter- and intra-specific associations of non-human primates in Anailmalai Hills, south India. *Mammalia 61*: 17-28

Skinner S W and Lockard J S 1979 An ethogram of the liontail macaque (*Macaca silenus*) in captivity. *Applied Animal Ethology 5*: 241-253

Skyner L, Amory J and Hosey G 2004 The effect of visitors on the self-injurious behaviour of a male pileated gibbon (*Hylobates pileatus*). *Der Zoologische Garten 74*: 38-41

Smith A, Lindburg D G and Vehrencamp S 1989 Effect of food preparation on feeding behaviour of lion-tailed macaques. *Zoo Biology 8*: 57-65

Smith T 2004 *Zoo Research Guidelines: Monitoring Stress In Zoo Animals*. The Federation of Zoological Gardens of Great Britain and Ireland: London, UK 17p

Snowdon C T 1991 Naturalistic environments and psychological well-being. Novak M A and Petto A J (Eds) *Through the Looking Glass*. pp 103-115 American Psychological Association: Washington DC, USA

Sokal R R and Rohlf F J 1995 *Biometry*. Freeman: New York, USA 887p

Soule M E and Wilcox B M 1980 *Conservation Biology: An Ecological-Evolutionary Perspective*. Sinauer Associates: Sunderland, USA

Steen Z 1995 Effects of enriched food acquisition on activity budgets of two tamarin species at Adelaide Zoo. *International Zoo News 42*: 284-298

Stoinski T, Beck B, Bowan M and Lehnhardt J 1997 The gateway zoo program: a recent initiative in Golden Lion Tamarin reintroduction. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 113-130 American Society of Primatology: Oregon, USA

Sugiyama Y 1998 Local variation of tool-using repertoire in wild chimpanzees. In: *Comparative Study of the Behavior of the Genus Pan by compiling Video Ethogram* pp 82-91. Nissindo Printer: Kyoto, Japan

Terlouw E M C, Schouten W G P and Ladewig J 2000 Physiology. In: Appleby M C and Hughes B O (Eds) *Animal Welfare*. pp 143-158 CAB International: Oxon, UK

Thomas W D and Maruska E J 1996 Mixed-species exhibits with mammals. In: Kleiman D G, Allen M G, Thompson K V, Lumpkin S, (Eds) *Wild Mammals in Captivity: Principles and Techniques*. pp 204-211 University of Chicago Press: Chicago, USA

Tunnicliffe D S 2002 Is the conservation message 'read' by primary school groups and families visiting zoos? *Society of Conservation Biology 16th Annual*

Meeting co-hosted by DICE and the British Ecological Society. p 14 Kent, UK

Umapathy G and Kumar A 2000a Demography of the lion-tailed macaque (*Macaca silenus*) in rainforest fragments of Anamalai Hills, South India. *Primates 41*: 119-126

Umapathy G and Kumar A 2000b Impacts of the habitat fragmentation on time budget and feeding ecology of lion-tailed macaque (*Macaca silenus*) in rainforest fragments of Anamalai Hills, South India. *Primate Report 58*: 67 – 82

Venugopal B and Sha A A 1993 Visitor behaviour at lion-tailed macaque in the Mysore Zoo. *Zoos' Print 8*: 45-48

Vick S J, Anderson J R and Young R 2000 Maracas for Macaca? Evaluation of three potential enrichment objects in two species of zoo-housed macaques. *Zoo Biology 19*: 181-191

Waitt C and Buchanan-Smith H M 2001 What time is feeding? How delays and anticipation of feeding schedules affect stump-tailed macaque behavior. *Applied Animal Behaviour Science 75*: 75-85

Walker S and Molur S 2003 South Asian Primate C.A.M.P Summary. Coimbatore, India 30p

Wallis J 1997 From ancient expeditions to modern exhibitions: The evolution of primate conservation in the zoo community. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 1-27 American Society of Primatology: Oregon, USA

Weber A W 1987 Socioecologic factors in the conservation of afromontane forest reserves. In: Marsh C W and Mittermeier R A (Eds) *Primate Conservation in The Tropical Rain Forest*. pp 205-229 Alan R Liss: New York, USA

Weber B and Vedder A 2001 *In the Kingdom of Gorillas: Fragile Species in a Dangerous Land*. Simon and Schuster: New York, USA 384p

Webster A J F, Main D C J and Whay H R 2004 Welfare assessment: indices from clinical observation. *Animal Welfare Supplement 13*: S93-S98

Westoby M 1974 An analysis of diet selection by large generalist herbivores. *American Naturalist 113*: 691-703

Wielebnowski N C 1999 Behavioural differences as predictors of breeding status in captive cheetahs. *Zoo Biology 18*: 335-349

Wiese R J and Hutchins H 1997 The role of North American zoos in primate conservation. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 29-42 American Society of Primatology: Oregon, USA

Wilson M, Kelling A, Poline L, Bloomsmith M and Maple T 2003 Post-occupancy evaluation of zoo Atlanta's giant panda conservation center: staff and visitor reactions. *Zoo Biology 22*: 365 – 382

Wood W 1998 Interactions among environmental enrichment, viewing crowds, and zoo chimpanzees (*Pan troglodytes*). *Zoo Biology 17*: 211 – 230

World Resource Institute 1990 *World Resources: A Guide to the Global Environment. World Resources Institute.* Oxford University Press: Oxford, UK 383p

Worlein J M and Sackett G P 1997 Social development in nursery-reared pigtailed macaques (*Macaca nemestrina*). *American Journal of Primatology* 41: 23-35

Young R J 2003 Environmental enrichment for captive animals. UFAW Animal Welfare Series. Blackwell Publishers: Oxford, UK 240p

Zeeve S and Porton I 1997 Zoo-based conservation of Malagasy prosimians. In: Wallis J (Ed) *Primate Conservation: The Role of Zoological Parks*. pp 83-95 American Society of Primatology: Oregon, USA

Zimmerman A and Feistner A T C 1996 Effects of feeding enrichment on ruffed lemurs *Varecia variegata variegata* and *Varecia v. rubra. DODO (Journal of Durrell Wildlife Conservation Trust) 32*: 67-75

Zinner D, Hindahl J and Kaumanns W 2001 Experimental intergroup encounters in lion-tailed macaques (*Macaca silenus*) *Primate Report 59*: 77-92

Zucker E L, Deitchman M and Watts E 1991 Behavioural evaluation of exhibit modifications designed to accommodate an aged Diana monkey. *Zoo Biology 10*: 69-74

Appendices

Name of Zoo:

APPENDIX 3.1
SURVEY ON THE LION-TAILED MACAQUES (*Macaca Silenus*) HOUSED IN ZOOS

PLEASE TICK THE APPROPRIATE BOXES

1. How many lion-tailed macaques (LTM) do you have in your zoo?

1 to 5	6 - 15	More than 15

How many male, females and young [*Please mention numbers*]?

Males	Females	Young

2. Are they housed in group(s)?

Yes	No

If they aren't housed in groups why?

3. How big is their enclosure (*Please mention approximate size in appropriate box*)?

< 50 sq. ft (15 m^2)	51 – 150 sq. ft (15 – 45 m^2)	>150 sq. ft (45 m^2)

4. What kind of enclosure are they housed in?

a.

Island exhibit	Glassed	Moated exhibit	Free-ranging	cage

b. Are they?

Indoors	Outdoors

5. Do they have trees/plants or water in their enclosure?

	Yes	No
Trees/ plants		
Water		

6. Do they exhibit the following behaviour

Foraging		Climbing	
Grooming		Calling	
Aggression		Abnormal behaviour	

7. What forms of abnormal behaviour do they exhibit?

8. What do you feed your LTM with [*please mention approximate quantities fed*]?

	Quantity [kg]		Quantity [kg]
Formulated diet		Fruits/ Vegetables	
Meat/ Eggs		Insects	

9. Can visitors interact with LTM? Do they feed them?

	Yes	No
Interact with LTM		
Feed LTM		

10. How often do you provide enrichment to your LTM?

One a week	More than once a week	Once a month	Less than a month	Not at all

Name of Zoo:

11. Briefly describe the forms of enrichment

12. How many young were born over the past 5 years [*Please mention numbers born*]?
How many animals have died over the past 5 years [*Please mention numbers died*]?

13. How many of the females mentioned in question 1 have bred [*Please mention numbers*]?

14. How many infants have survived to adulthood [*Please mention numbers*]?

	Yes	No
15. Are LTM breeding in you zoo?		
16. Is your zoo a part of any national or International LTM conservation breeding programme		

17. If yes, which breeding programme?

Additional information [any information that you would like to include could be added here

APPENDIX 4.1

THE ETHOGRAM

Fifty-pne lion-tailed macaques were studied across 13 zoos. Twenty behavioural states and 110 behavioural events exhibited by these captive lion-tailed macaques have been detailed in the ethogram below.

A. BEHAVIOURAL STATES

Behavioural states have been categorised into abnormal and normal behaviours.

1. ABNORMAL BEHAVIOURS refer to behavioural pathologies that occur under conditions of captivity. Like most forms of abnormal behaviours, the six behavioural states observed in this study are idiosyncratic and repetitive, and can be exhibited for durations ranging from a few seconds to several minutes. Abnormal behaviours can be either qualitative or quantitative.

1.1 Qualitative behavioural pathologies are behaviours that are qualitatively different in being exhibited only in captivity and almost never in the wild. These behaviours have been further classified into self- directed behaviours and social interactions or behaviours directed to other individuals.

1.1.1 Self-directed behaviours: these behaviours are directed towards oneself. They have been further divided into novel behavioural pathologies and behavioural interchanges.

a. Novel behavioural pathologies – these are behaviours that are not exhibited in the wild but are only displayed by captive individuals. The behaviours included in this category are:

i. Circle repetitively: repetitive circling in small circles is a form of stereotyped locomotor behaviour. The speed with which an animal circles depends on individual anxiety and levels of stress.

This behaviour was exhibited by one confiscated, probably isolate-reared male, housed in Thiruvananthapuram Zoo.

ii. Floating limb: a unique pattern of movement of limbs where one limb begins a slow upward movement while the animal is in the seated position or a slow backward movement while in the standing position. The animal does not notice this behaviour initially. When the floating limb is noticed, it is visually tracked for a short period of time and then attacked. In several cases, individuals severely mutilate the floating limb. Individuals often stop the limb from floating by forcibly holding it down. Sometimes this behaviour is accompanied by fear-screaming.

The study individuals spent a 4.3 ± 1.3% of their time exhibiting this behaviour (N = 7[1]). This behaviour was mostly frequently displayed by confiscated, probably isolate-reared, individuals.

iii. Pluck hair: this refers to the repetitive plucking of one's own hair; occasionally this behaviour may be directed by a female towards her infant.

Hair-plucking was exhibited infrequently by a socially-deprived male and more repetitively by a female who directed it towards her infant. The singly-housed male tended to pluck hair only from his facial mane while the female spent approximately 0.9% of the observed time plucking hair from the infant's back.

iv. Stereotypic pacing: this refers to the idiosyncratic repetitive pacing along the same path by an individual. It involves a back and forth movement along one wall of the cage – usually the point furthermost from the visitor area.

[1] N = number of individuals exhibiting the behaviour in question

Stereotypic pacing was exhibited 11.3 ± 2.9% of the time (N = 14). Pacing was exhibited more frequently by confiscated animals than by zoo-born individuals housed in barren, sub-optimal environments.

b. Behavioural interchanges – these are behaviours that are normally directed towards other animals under natural conditions, but towards oneself in captivity.

i. **Self-biting:** biting hand, foot or any other part of ones own body. This behaviour causes the individual to sometimes mutilate itself drawing blood occasionally. Individuals either bite their forelimb or hind-limb. Floating limb is sometimes followed by the individual biting the limb that is floating which is almost always the hind-limb.

Self-biting was exhibited mostly by confiscated individuals. One animal exhibited self-biting 0.87 proportion of the time.

1.1.2 Social interactions: these refer to abnormal behaviours exhibited towards other individuals, people or the environment. This category has been further divided into novel behavioural pathologies and behavioural interchanges.

a. Novel behavioural pathologies – these are behaviours that are not exhibited in the wild but are exhibited only by captive individuals.

i. **Beg:** The individual stretches its forelimb towards visitors or the zoo staff. Visitors often carry edible food items that are visually tracked by the individual before the behaviour is exhibited.

Individuals that exhibited this behaviour were from all age classes and were housed in small, barren cages. Due to the short visitor distances in these small cages, visitors could get close to the animals and interact with the animals. This behaviour was exhibited 4.5 ± 1.7% of the time (N = 6).

2. NORMAL BEHAVIOURS

This category includes behaviours that are exhibited at comparable levels by both free-ranging and captive individuals. This category has been further divided into self-directed behaviours and social interactions.

2.1. Self-directed behaviours are behaviours that an individual directs towards itself. These behaviours can be classified into four categories – active behaviours, rest behaviours, food-related behaviours and autogrooming.

2.1.1. Active behaviours: this refers to the continuous movement in a particular direction on any substratum by the individual. Active behaviours include climbing, running and walking.

i. **Climb:** climbing either up or down on any substratum such as a tree or an elevated platform.

Individuals from all age-, sex- and rearing history classes exhibited this behaviour; on an average, it was performed 5.0 ± 0.7% of the time (N = 31). Individuals housed in larger enclosures climbed more than those housed in cages.

ii. **Run:** movement with very quick pace in a particular direction, on any horizontal or slightly inclined substratum.

This behaviour was exhibited 2.5 ± 0.8% of the time (N = 12) at a fast or slow pace, by individuals of all sex-, age- or rearing history classes.

iii. **Walk:** movement by the individual in a particular direction on any horizontal or slightly inclined substratum.

This behaviour was exhibited 10.1 ± 1.0% of the time (N = 51) at a fast or slow pace by individuals from all sex-, age- or rearing history classes.

2.1.2. *Rest behaviours:* these refer to certain behaviours with relaxed posture, displayed on any substratum. Being essential behavioural states, individuals of all sex-, age- and rearing history classes exhibited them. This category includes four behavioural states – lying down, sitting, sleeping and standing.

i. **Lying down:** resting flat on any substratum, sometimes with the head hanging off a branch and the limbs spread out. While exhibiting this behaviour, the eyes remain open and the individuals are completely awake.

This behaviour was exhibited 3.9 ± 2.0% of the time (N = 11).

ii. **Sit:** involves sitting in a relaxed fashion on any substratum, often without exhibiting a specific interest in any object, individual or event.

Sitting was exhibited 39.8 ± 2.8% of the time (N = 51) and was observed commonly among individuals of all age- and sex classes.

iii. **Sleep:** individuals sleep either in the sitting position or while lying down – with the eyes closed in either situation.

Animals were observed to sleep in the afternoon and after feeding time. This has been observed commonly among individuals of all age- and sex classes and, on an average, occupied 4.2 ± 1.6% of the observed time (N = 16).

iv. **Stand:** individuals usually stand on all four limbs on any substratum, often without exhibiting a specific interest in any object, individual or event.

This behaviour was observed commonly among individuals of all age- and sex classes; they spent approximately 8.4 ± 1.0% of their time in this state (N = 47).

2.1.3 *Food-related behaviours:* these refer to behaviours related to searching for food and feeding. Foraging and feeding are the most essential activities for free- ranging non-human primates and occupies a considerable proportion of their activity budget. This category includes three behavioural states – feeding, active foraging and passive foraging.

i. **Feed:** involves the process of handling the food item, active ingestion and the act of chewing while consuming it.

This behaviour occupied 8.0 ± 1.0% of the time spent by individuals irrespective of age, sex and rearing history (N = 46).

ii. **Forage – active:** involves the active searching for food items either on the enclosure floor or on the trees and branches provided in the enclosure, as well as the subsequent handling and manipulating of the forage.

This behaviour was exhibited 8.6 ± 1.2% of the time (N = 39). Females actively foraged more than males did. Individuals housed in complex enclosures exhibited higher levels of active foraging than those housed in cages.

iii. **Forage – passive:** involves individuals sitting or standing alertly and scanning, either the enclosure floor or trees, branches and twigs for potential food items.

Individuals spent approximately 4.6 ± 0.8% of their time (N = 19) exhibiting this behaviour. Individuals housed in dry moated enclosures exhibited higher levels of passive foraging than those housed in wet moated enclosures or cages.

2.1.4 Autogroom: refers to the grooming of any part on the body of the actor, active searching for dirt, ectoparasites or insects that might be entangled in its hair.

Individuals of all age-, sex- or rearing history classes exhibited this behaviour an average of 4.9 ± 0.7% of the time (N = 37). Females autogroomed more than did males.

2.2 **Social interactions** refer to behaviours directed by one individual (actor) towards another (target), the latter being a member of the captive group, an animal housed in the neighbouring enclosure, zoo staff, observer, visitor or any feral animal in the vicinity. This category includes allogrooming, mating, playing and suckling.

i. **Allogroom:** individuals groom any part of the body of another individual actively looking for fragments of dirt, insects, ectoparasites and other foreign particles in the hair.

This behaviour was exhibited 3.5 ± 0.7% of the time (N = 20). Individuals housed singly were observed to groom their neighbours, on most occasions, animals of a different species. Individuals of all ages, sexes and rearing history classes, allogroomed; infants often observed their mothers closely and then allogroomed them. In several cases, individuals were observed to groom each other simultaneously.

ii. **Mate:** refers to the mounting of one individual by another; this behaviour usually involves sexually mature males and females.

This behaviour was exhibited by sub-adult and adult animals approximately 1.2 ± 0.3% of the time (N = 3).

iii. **Play:** this involves two or more individuals wrestling, mock fighting, lunging, jumping, teasing, running or chasing one another.

Playing was most frequently observed in infants, juveniles and sub-adults and they spent about 14.5 ± 4.8% of their time in this behaviour (N = 9). Individuals housed only with adults were observed to play by themselves or to tease adults. Of the adults, only parents were observed to play with their young, while younger parents tended to play relatively more.

iv. **Suckle:** an infants feeding on its mother's breast milk.

Suckling was only exhibited by infants, though some juveniles tried to suckle but were pushed away by their mothers. Lactating females were usually observed to push away infants more than 10 months of age. An infant in Bhilai Zoo spent about 3.5% of its time being suckled.

B. BEHAVIOURAL EVENTS

Behavioural events have been further classified into abnormal and normal behaviours.

1. ABNORMAL BEHAVIOURS refer to behavioural pathologies that occur in captivity. There are 41 behavioural events that have been categorised under qualitative and quantitative abnormal behaviours.

1.1 Qualitative behavioural pathologies are behaviours that are only exhibited in captivity and are usually not encountered in the wild. These behaviours are further classified into self- directed behaviours and social interactions.

1.1.1 Self-directed behaviours: these include behaviours that are directed towards oneself. This category has been further classified into novel behavioural pathologies and behavioural interchanges.

<u>a. Novel behavioural pathologies</u> – these are behaviours that are not exhibited by individuals in the wild but develop under conditions of captivity. This category includes 14 behavioural events.

i. Bouncing: this behaviour refers to the repetitive jumping up and down on the enclosure floor on all fours.

This behaviour was only observed in six confiscated, hyper-aggressive individuals housed in a barren, sub-optimal environment. They exhibited this behaviour at the frequency of 1.02 ± 0.2 event/h.

ii. Circle repetitively: repetitive circling in small circles is another stereotyped locomotor behaviour shown by captive individuals.

This behaviour was exhibited by one confiscated, probably isolate-reared male housed in Thiruvananthapuram Zoo (8.77 events/h).

iii. Floating limb: a unique pattern of movement of limbs where one limb begins a slow upward movement while the animal is in the seated position or a slow backward movement while in the standing position. Although this behaviour is better considered as a behavioural state, the frequency with which episodes of floating limb occur can also be recorded during focal animal sampling.

Episodes of floating limb were initiated at a frequency of 3.1 ± 1.7 event/h ($N = 5$), and were most commonly observed in confiscated, probably isolate-reared, individuals.

iv. Head toss: this refers to an upward movement of the head, usually exhibited at the end of a bout of stereotypic pacing. This behaviour is exhibited only when the individual is moving.

Only confiscated individuals exhibited head tossing, at an approximate frequency of 5.7 ± 3.4 event/h ($N = 6$).

v.Oral stereotypy: this behaviour consists of the repetitive rolling of the tongue while the animal is seated or standing. It is often accompanied by a soft rumbling vocalisation.

Only one confiscated male, probably isolate-reared, exhibited this behaviour 3.7 times an hour.

vi. Pluck hair: this refers to the repetitive plucking of one's own hair; occasionally this behaviour may be directed by a female towards her infant.

This behaviour was initiated approximately 1.0 ± 0.5 times an hour (N = 2); both individuals that exhibited these bouts were housed in barren cages.

vii. Regurgitate and re-ingest: this refers to the repetitive expulsion of ingested food, followed by its re-ingestion each time.

These behaviours were observed in confiscated individuals housed in barren, sub-optimal environments; they regurgitated and re-ingested at a frequency of 1.4 ± 0.8 event/h (N = 2) and 2.2 event/h (N = 1) respectively.

viii. **Rock:** this behaviour consists of a repetitive to-and-fro or sideways swaying movement of the body, while the animal is in a seated, partially seated or standing position and sometimes close to an object such as the enclosure wall.

One female housed at Mysore Zoo was observed to infrequently exhibit this behaviour, but only when she was off-exhibit.

ix. **Rub or lick nipple:** this refers to a repetitive pulling and licking of her own nipples by an individual.

This behaviour was exhibited at a frequency of 3.3 event/h by one confiscated female housed in a barren, sub-optimal environment.

x. Run with head up: while displaying this behaviour, an individual runs bipedally with its head held up at a 45° angle to the body.

This behaviour was exhibited infrequently by an adult female confiscated from a small, unrecognised zoo and was probably isolate-reared.

xi. Salute: this is a behaviour in which one hand is held up to the face just above the eyelid with one finger pressed against the corner of the eye. This behaviour is sometimes exhibited when the individual scanned its environment.

One male confiscated from a private owner exhibited this behaviour occasionally (1.14 event/h).

xii. Stereotypic pacing: this refers to the idiosyncratic repetitive pacing along the same path by an individual. It involves a back and forth movement along one wall of the cage – usually the point furthermost from the visitor area.

Stereotypic pacing bouts were initiated 8.9 ± 2.5 times an hour (N = 13). Sometimes, the pace of the behaviour increased when the animals appeared to be relatively more stressed. Pacing was exhibited more frequently by confiscated animals, rather than zoo-born individuals, housed in barren, sub-optimal environments.

xiii. Telescoping: this behaviour consists of an individual rolling her fingers into a cylinder-like structure and holding it up to the eye like a telescope to scan the immediate environment.

The behaviour was observed rarely during this study.

xiv. Weave: this refers to a repetitive movement of the head and shoulders from side to side, exhibited when the animal is either in the seated or in the standing position.

This behaviour was shown sporadically by an adult female confiscated from a small unrecognised zoo and probably isolate-reared as well.

b. Behavioural interchanges – these are behaviours that are normally directed towards conspecifics in the wild but are directed towards oneself under captive conditions. This category includes six behavioural events.

i. **Affiliative bared-teeth face:** this behaviour is exhibited as a display of the teeth when lips are pulled apart with the corners drawn backwards. It is a communicative gesture exhibited in non-agonistic situations. It is closely associated with affiliative grunt and is frequently accompanied by this vocalisation.

All individuals irrespective of age, sex or rearing history exhibited this behaviour. Some individuals exhibited this behaviour to themselves as frequently as 4.0 ± 3.2 times an hour ($N = 9$).

ii. **Affiliative grunt:** this is a short grunt-like vocalisation in a non-agonistic situation with another individual.

It is mostly exhibited by adults with some adults exhibiting this behaviour 0.8 ± 0.3 ($N = 8$) times an hour to themselves.

iii. **Bared-teeth display:** this is a prolonged deliberate yawn that fully exposes the canines of the individual. This is an aggressive display gesture and is often directed to visitors and staff, neighbouring animals and strange animals that pass their enclosure.

It is mostly exhibited by adults; with some individuals exhibiting this behaviour to themselves to a frequency of 0.9 ± 0.4 ($N = 5$).

iv. **Eye flash:** this behaviour involves lifting of eyebrows to exposing the eyelids in a sudden jerky movement by pulling the forehead back. This behaviour is frequently exhibited towards visitors, zoo staff or strange animals that pass the enclosure. Adults and sub-adults most frequently exhibit these behaviours especially hyper-aggressive socially deprived males.

This behaviour was exhibited at a frequency of 1.4 ± 0.8 ($N = 10$) by some individuals to themselves.

v.**Self-biting:** this behaviour involves the biting of a hand, foot or any other part of ones own body. This behaviour causes the individual to sometimes mutilate itself drawing blood occasionally. Individuals either bite their forelimb or hind-limb. Floating limb is sometimes followed by the individual biting the limb that is floating which is almost always the hind-limb.

Self-biting was exhibited mostly by confiscated individuals. Animals exhibited self-biting as frequently as 1.16 ± 0.31 event/h for the forelimb ($N = 7$) and 0.7 ± 0.3 event/h for the hind-limb ($N = 7$).

vi. **Warning growl:** this vocalisation is usually emitted during agonistic reactions. It is a low growl-like vocalisation. Animals irrespective of age, sex or rearing history exhibit this behaviour.

This behaviour was exhibited by some animals towards themselves at a frequency of 3.1 ± 1.2 ($N = 13$).

1.1.2 Social interactions: These refer to abnormal behaviours that are directed towards other individuals. These behaviours are further classified into novel behavioural pathologies and behavioural interchanges.

a. Novel behavioural pathologies – these are behaviours that are usually not exhibited in the wild but occur quite commonly in captivity. This category includes only four behaviours.

i. **Beg:** The individual stretches its forelimb towards visitors or the zoo staff. Visitors often carry edible food items that are visually tracked by the individual before the behaviour is exhibited.

Individuals that exhibited this behaviour were from all age classes and were housed in small, barren cages. Due to the short visitor distances in these small cages, visitors could get close to the animals and interact with the animals. This behaviour was exhibited 4.5 ± 1.8% of the time, while begging bouts were initiated 3.1 ± 0.8 times an hour (N = 13).

ii. **Body shake with lip-smack:** the individual repetitively bends forward, while seated, and straightens up again with its hands on the belly, lipsmacking all the while.

This behaviour was sometimes exhibited towards other animals but mostly directed towards humans. The female, which exhibited this behaviour at a frequency of approximately 6.4 event/h, was an adult confiscated from a small unrecognised zoo.

iii. **Hold penis:** this behaviour consists of a male continuously holding his penis while in a seated or standing position. This behaviour is usually only exhibited when humans are present with the individual eye-flashing or lip- smacking at visitors or sometimes even the zoo staff while displaying the behaviour.

This behaviour was exhibited at a frequency of 0.8 ± 0.4 event/h (N = 7), mostly by males who were confiscated small unrecognised zoos and were probably isolate-reared individuals.

iv. **Splash water:** this behaviour refers to an individual putting its hand into water and splashing it on unsuspecting visitors or the zoo staff.

This behaviour was exhibited as frequently as 3.8 ± 2.2 event/h (N = 6) by hyper-aggressive, singly-housed, confiscated males.

b. Behavioural interchanges – these are behaviours that are normally directed towards other animals under natural conditions, but towards oneself in captivity. This category consists of only one behaviour: auto-erotic stimulation.

i. **Auto-erotic stimulation:** this refers to self-directed sexual activity observed only in individuals reared and housed in a socially- deprived environment. The different behavioural components are: **Bipedal walk with masturbation:** holding penis/masturbating while bipedally standing. This behaviour is only exhibited when humans are present, the individual eye-flashing at visitors or zoo staff while exhibiting the behaviour. Only one adult male exhibited this behaviour at a frequency of 2.0 event/h. He was confiscated from a private owner and was probably an isolate-reared individual. **Masturbating – copulatory grimace:** the manipulation of genital organs by rubbing the penis with the hands, shown by sexually mature males, often resulting in a visible erection of the penis and a subsequent ejaculation. This behaviour was exhibited 2.6 ± 3.5 times an hour (N = 3) towards humans – most frequently zoo visitors – and was always accompanied with the exhibition of copulatory grimace by the individual. Only confiscated males that were isolate-reared exhibited this behaviour.

1.2 Quantitative behavioural pathologies refer to behaviours that are exhibited either at significantly (ten times) higher or lower frequencies in captivity than in the wild. These behaviours can be further classified into self-directed behaviours and social interactions, directed towards other individuals (refer to Raghavan (2001) for data on free-ranging lion-tailed macaques).

1.2.1 Self-directed behaviours: these are behaviours that are preferentially directed by individuals towards themselves. This category consists of four behaviours.

i. **Body shake:** this refers to the vigorous shaking of the torso, often to dislodge fragments of leaves or twigs and occasionally to shake off water after the rains.

Individuals irrespective of age, sex or rearing history exhibited this behaviour significantly higher than free-ranging lion-tailed macaques at an average frequency of 2.0 ± 0.2 event/h (N = 18)

ii. **Inspect penis:** this behaviour refers to the inspection of the penis by sexually mature males with their hands; some were observed to subsequently smell their fingers or lick their palms.

When compared with data collected free-ranging lion-tailed macaques (Raghavan, 2001), it was found that the captive males exhibited this behaviour to a significantly higher frequency of (0.9 ± 0.2, N = 15).

iii. **Masturbation:** this behaviour refers to the manipulation of genital organs by rubbing the penis with their hands by sexually mature males, often resulting in a visible erection of the penis and a subsequent ejaculation.

When compared to data collected from the wild, (Raghavan, 2001), it was found that 12 individuals exhibited a significantly higher proportion of this behaviour to a frequency of 0.9 ± 0.1.

iv. **Scratch body:** this behaviour refers to individuals scratching different parts of their body often without being overtly attentive to the act.

Only one individual was found to exhibit this behaviour 44.7 times an hour is was 10 times higher than the frequency levels exhibited by free-ranging individuals

v.Yawn: this behaviour refers to when individuals open their mouth wide and breathe in, usually observed after feeding and resting bouts. Individuals irrespective of age, sex or rearing history exhibit this behaviour.

Twenty-four captive individuals exhibited this behaviour to a frequency of 6.1 ± 0.6 which was significantly higher than frequencies exhibited by their free-ranging counterparts

vi. **Autogroom:** this refers to the grooming of any part on the body of the actor, active searching for dirt, ectoparasites or insects that might be entangled in its hair.

Autogrooming bouts were initiated at a frequency of 4.6 ± 0.7 event/h by 44 individuals in captivity. This was 10 times higher than frequencies exhibited by free-ranging individuals and hence autogrooming has been included in quantitative behavioural pathologies

1.2.2 Social interactions: these refer to abnormal behaviours directed towards other individuals. This category includes four behavioural events.

i. **Affiliative bared-teeth face:** this behaviour refers to a display of the teeth when lips are pulled apart with the corners drawn backwards. It is a communicative gesture exhibited in non-agonistic situations. It is closely associated with affiliative grunt and is frequently accompanied by this vocalisation.

All individuals irrespective of age, sex or rearing history exhibited this behaviour. Confiscated animals were observed to exhibit this behaviour to humans. Twelve individuals exhibited this behaviour 10 times higher to a frequency of 8.3 ± 2.0 event/h than exhibited by free-ranging animals

ii. **Bared-teeth display:** this refers to a prolonged deliberate yawn that fully exposes the canines of the individual. This is an aggressive display gesture and is often directed to visitors and staff, neighbouring animals and strange animals that pass their enclosure.

This behaviour was most frequently observed by hyper-aggressive singly-housed males that exhibited this behaviour at frequencies of 3.9 ± 0.9 that was significantly higher than frequencies exhibited in the wild.

iii. **Eye flash:** this refers to the lifting of eyebrows to exposing the eyelids in a sudden jerky movement by pulling the forehead back. This behaviour is frequently exhibited towards visitors, zoo staff or strange animals that pass the enclosure. Adults and sub-adults most frequently exhibit these behaviours especially hyper-aggressive socially deprived males.

This behaviour was exhibited as frequently as 5.6 ± 1.2 (N = 37) which was ten times higher than frequencies exhibited by free-ranging lion-tailed macaques.

2. NORMAL BEHAVIOURS

This category includes behaviours that are exhibited at comparable levels by both free-ranging and captive individuals. This category has been further divided into self-directed behaviours and social interactions.

2.1 Self-directed behaviours are behaviours that an individual directs towards itself. This category consists of 23 behavioural events.

i. **Alarm call:** Short gruff-like vocalisations emitted when the individual is startled, or in response to alarm calls given by other individuals.

These calls were usually directed towards other animals and humans, and were exhibited at a frequency of about 0.4 ± 0.1 event/h (N = 10).

ii. **Bipedal alert:** this behaviour consists of an individual attentively looking at a particular object or individual in a specific direction while standing bipedally.

This behaviour was exhibited only when the animal stood on the enclosure floor. By standing on its hind limbs, an individual could view the environment above the enclosure wall. This behaviour was exhibited 2.1 ± 0.6 times an hour (N = 28) by individuals from all age- and sex classes.

iii. **Body shake:** this refers to the vigorous shaking of the torso, often to dislodge fragments of leaves or twigs and occasionally to shake off water after the rains.

Individuals irrespective of age, sex or rearing history exhibited this behaviour at an average frequency of 0.7 ± 0.04 event/h (N = 26).

iv. **Cough:** this behaviour may be the result of temporary choking during feeding bouts, during regurgitation, or could manifest as a result of a suspected ailment or infection.

This behaviour was exhibited at a frequency of 0.3 ± 0.1 event/h (N = 9) by individuals of all age and sex classes.

v.**Defecate:** individuals may defecate while seated or standing on any substratum.

This behaviour was rarely observed and only three males exhibited this behaviour – at a frequency of 0.2 ± 0.02 times an hour.

vi. **Drink:** this behaviour is manifest by an individual lying supine or bending over, placing its mouth directly at the edge of the water body or water trough and lapping it up. Occasionally, water may also be scooped out with the hand and then licked off the palm or by averting the tongue during rain and lapping up the water drops as they fall.

This behaviour was exhibited at a frequency of 0.8 ± 0.1 event/h (N = 29) by individuals of all classes.

vii. **Ejaculate and lick semen:** this behaviour occurs when a mature male ejaculates and licks the semen off its hand.

Socially-deprived mature males were observed to exhibit this behaviour more frequently than did males housed in captive groups (deprived males: 1.3 ± 0.5 event/h, N = 6; males housed with females: 0.2 ± 0.1 event/h, N = 3).

viii. **Hiccup:** this typically refers to the sudden stopping of the breath with a sound like a soft cough.

This behaviour was exhibited 1.1 ± 0.5 times an hour (N = 9), usually during feeding.

ix. **Jump:** individuals jump from one area to another on all kinds of substratum, but most frequently from branch to branch.

Individuals irrespective of age, sex or rearing history exhibited this behaviour as frequently as 3.3 ± 0.7 times an hour (N = 40).

x.**Lick hand:** this refers to the licking of the palms and fingers of the hand.

Individuals irrespective of age, sex or rearing history exhibited this behaviour, at an average frequency of 1.1 ± 0.4 event/h (N = 26).

xi. **Lick object:** this refers to the licking of any external object such as the cage bars, tree trunks or enclosures walls.

This behaviour was exhibited 0.6 ± 0.1 times an hour (N = 17).

xii. Masturbation: the manipulation of genital organs by rubbing the penis with their hands by sexually mature males, often resulting in a visible erection of the penis and a subsequent ejaculation.

One individual exhibited this behaviour to a frequency of 0.2. Twelve other individuals exhibited masturbation but to abnormally high frequencies (refer to quantitative behavioural pathologies).

xiii. Scan: an individual sit or stands and looks around attentively at its surroundings.

This behaviour was exhibited 4.0 ± 1.1 times an hour (N = 39), most frequently when individuals were in the elevated reaches of the enclosure. Adult males most frequently displayed this behaviour, although certain females were also observed to scan the surrounding areas occasionally (males: 4.8 ± 1.7 event/h, N = 23; females: 1.4 ± 0.7 event/h, N = 17).

xiv. Scratch body: this behaviour consists of the scratching of different parts of the body inattentively.

Individuals irrespective of age, sex or rearing history exhibited this behaviour, with an average frequency of 14.9 ± 1.1 event/h (N = 44).

xv. Sneeze: this behaviour is fairly similar to the human sneeze and is exhibited by all age, sex and rearing history classes.

Individuals were observed to sneeze 0.6 ± 0.2 times an hour (N = 14).

xvi. Stretch: the individual stretches its body while standing.

Only one individual exhibited this behaviour during the study – at a frequency of 0.2 event/h.

xvii. **Swing or brachiate:** this locomotor behaviour consists of the individual moving from branch to branch with the help of its forelimbs or simply hanging by the forelimbs from these branches.

Individuals from all classes except infants exhibited this behaviour as frequently as 1.3 ± 0.7 times an hour (N = 7). Individuals housed in complex exhibits were able to brachiate more than were animals housed in impoverished environments.

xviii. **Swipe at insect:** individuals often forage by moving their hands vigorously to catch hovering insects such as flies, ants, grasshoppers and mosquitoes for food. Sometimes they wave their hands in front of their faces to drive insects away.

Individuals irrespective of age, sex or rearing history exhibited this behaviour an average of 1.1 ± 0.2 times an hour (N = 42); it was most frequently exhibited during the rainy season when the rain flushed insects out of the bushes. Individuals housed in dry moated enclosures exhibited higher levels of swiping compared to those housed in cages and wet moated enclosures. Animals maintained in enclosures with a soft substrate also exhibited higher levels of this behaviour.

xix. **Urinate:** Individuals may urinate while seated or standing on any substratum.

Individuals of all age- and sex classes exhibited this behaviour, with an average frequency of 0.3 ± 0.1 event/h (N = 15).

xx. **Wipe mouth or nose:** the use of the palm to wipe the mouth or the nose.

This behaviour was exhibited 1.7 ± 0.2 times an hour (N = 42) by individuals belonging to all classes.

xxi. **Yawn:** this behaviour, very similar to yawning in humans and consists of the wide opening of the mouth to breathe out and breath in.

This behaviour was exhibited 0.3 ± 0.1 times an hour (N = 13), usually after feeding and resting bouts. Individuals irrespective of age, sex or rearing history exhibited this behaviour. Twenty-four other individuals exhibited this behaviour to abnormally high frequencies and hence have been explained under behavioural pathologies.

2.2 Social interactions refer to events involving behavioural interactions between two or more individuals. Sometimes the target individual could be another captive species housed in a neighbouring enclosure, other free-ranging animals, zoo staff, visitors or even the observer. This category has been further divided into affiliative, reproductive, aggressive, infant-related, neutral and play behaviours.

2.2.1. Affiliative behaviours: this category includes affiliative social interactions and includes seven types of behaviours described below:

i. **Affiliative bared-teeth face:** a display of the teeth when lips are pulled apart with the corners drawn backwards. It is a communicative gesture usually exhibited in non-agonistic situations. It is closely associated with the affiliative grunt and is frequently accompanied by this vocalisation.

Individuals from all age-, sex- or rearing history classes exhibited this behaviour, at a frequency of 1.15 ± 0.1 event/h (N = 25). Confiscated animals were usually observed to direct this behaviour towards humans.

ii. **Affiliative grunt:** this is a short grunt-like vocalisation expressed during non-agonistic interactions with another individual.

This behaviour was exhibited 1.3 ± 0.3 times an hour (N = 28) by confiscated individuals who preferentially directed it towards humans.

iii. **Contact call:** a “coo” vocalisation made by an individual, this call is most frequently exhibited when the animals are foraging or just before feeding time.

All individuals irrespective of their age, sex or rearing history exhibited this behaviour. Contact call was exhibited 5.9 ± 0.5 (N = 33).

iv. Follow: one individual follows another along the same path as the latter moves, invariably with an intention to approach it.

This behaviour was exhibited by individuals of all age, sex and rearing history classes, but most frequently displayed by infants while following their mothers. Follow was exhibited at an average frequency of 0.8 ± 0.2 event/h (N = 17).

v. Hold: an individual holds another by any part of the latter's body.

This behaviour was exhibited 0.37 ± 0.1 times an hour (N = 11).

vi. Mouth touch: when one individual touches the mouth of another individual with its mouth in an affiliative gesture.

The behaviour was most frequently directed by young animals towards sub-adults or adults. Mouth touch was exhibited an average of 0.5 ± 0.1 times an hour (N = 12).

vii. Touch: when one individual reaches out and touches any part of the body of another individual. Singly housed animals often reach out across the bars or their cages and touch neighbouring individuals.

This behaviour was exhibited by two individuals, at a frequency of 0.2 ± 0.1 event/h.

2.2.2 Reproductive behaviours: these involve sexual interactions between sexually mature males and females in oestrus. This category includes nine behaviours.

i. Attempted mount: this behaviour involves the actor trying to mount a target individual while the latter tries to avoid being mounted.

Animals irrespective of age, sex and rearing history classes exhibited this behaviour at a frequency of 0.5 ± 0.3 event/h (N = 5).

ii. **Avoid mount:** involves an individual moving away from another individual, which tries to mount it.

Only a single individual was observed to exhibited this behaviour (0.1 event/h) during this study.

iii. **Copulatory call:** the female emits this call during copulation with a male. It sounds like a series of soft short "ughs".

iv. **Copulatory grimace:** the male sometimes grimaces during, or just before, he mounts the female to mate with her.

This behaviour was exhibited by females at a frequency of 0.5 ± 0.3 event/h (N = 5).

v. **Inspection:** males often inspect the female's genitalia prior to copulation. *Visual Inspection:* involves the male lifting the female's tail and examining her genitalia. This behaviour was exhibited 0.6 ± 0.2 event/h (N = 14) during the present study. *Olfactory Inspection:* involves sniffing of the female's genitalia by the male after he lifts her tail. Sometimes the male sniffs his fingers after touching the female's genitalia. This behaviour was exhibited 0.2 ± 0.02 times an hour (N = 5).

vi. **Move away:** the actor moves away from the target individual.

This behaviour was exhibited 0.6 ± 0.1 event/h (N = 20), usually in response to certain behaviours displayed by the other individual.

vii. **Present:** involves the actor standing in front of the target animal and presenting its rear to it.

Sometimes the actor approached the target animal to present while, on other occasions, the actor presented to the target individual when it approached the former. Subordinate and young animals presented to dominant and older animals, respectively. Females presented to males. Presenting was often accompanied by lipsmacking. On several occasions presenting by the actor to the target animal was reciprocated with mounting, inspection of the genitalia or ignoring by the target animal. Animals irrespective of age, sex or rearing history exhibited this behaviour, at an average frequency of 0.8 ± 0.2 event/h (N = 11).

viii. **Scream:** males sometimes produce this vocalisation when they copulate with females. Only mature males exhibited this behaviour – at a frequency of 0.4 ± 0.1 event/h (N = 6).

ix. **Simple mount:** when the actor wholly or partially mounts the target animal without any thrusting movement of the abdomen.

Sometimes the actor would mount the target when the target was seated. Males and females were also observed to mount individuals of the same sex. Animals irrespective of age, sex or rearing history classes exhibited this behaviour at a frequency of 0.5 ± 0.3 event/h (N = 9).

x.**Staccato call:** this vocalisation is produced by females in oestrus to attract the male's attention. The vocalisation is emitted in a series of loud short "aah".

Staccato calls were exhibited at a frequency of 0.4 ± 0.1 event/h (N = 6).

xi. **Thrusting mount:** involves the whole or partial mount of the target animal by the actor with thrusting movement of the abdomen. Males exhibit this behaviour when they mount females. This behaviour is sometimes accompanied by lipsmacking by either or both individuals.

Thrusting mount was exhibited approximately 0.6 ± 0.3 times an hour (N = 9).

2.2.3 Aggressive behaviours: all agonistic behaviours between individuals have been included in this category, consisting of 15 behaviours.

i. **Aggressive bark:** sharp bark-like vocalisation that an individual directs towards another individual during agonistic situations.

This behaviour was also directed towards visitors, zoo staff and sometimes towards feral animals that may pass by the enclosure. One individual exhibited this behaviour 0.1 times an hour during this study.

ii. **Aggressive bite:** the actor holds a target individual and mildly bites into its flesh.

This behaviour was never observed to draw blood. It was exhibited at a frequency of 0.3 ± 0.2 event/h (N = 2).

iii. **Bared-teeth display:** this is a prolonged deliberate yawn-like gesture that fully exposes the canines of the individual.

This is an aggressive display gesture that was often directed towards visitors and staff, neighbouring animals and feral animals that pass the enclosure. This behaviour was exhibited by 16 individuals at a frequency of 0.4 ± 0.1 event/h. Several other individuals exhibited this behaviour but since they exhibited significantly higher frequencies than exhibited by free-ranging animals, they have been included under quantitative behavioural pathologies.

iv. **Branch shake or display bounce:** this behaviour involves holding a branch, cage bars or any other enclosure furniture and shaking it, or jumping up and down on it vigorously. This behaviour is more frequently exhibited by males than females and almost never exhibited by infants or juveniles. The act and the noise produced while exhibiting it typically serves to attract attention towards the actor. This behaviour was frequently directed towards zoo staff and visitors, especially by hyper-aggressive, socially deprived males.

v.**Chase:** during agonistic situations, an individual may rush towards another and follow the latter at a close distance. The latter reacts by exhibiting a fear response to the actor. This behaviour could terminate in an act of contact aggression, which was rarely observed in the captive groups.

vi. **Crouch:** this behaviour involves physically bending down and cowering by an individual due to aggression directed by a dominant individual in the captive group. The animal is usually on all fours with legs tucked in under the torso. Crouching is usually accompanied by lipsmacking and sometimes by head-bobbing.

This behaviour was exhibited at a frequency of 0.5 ± 0.3 event/h ($N = 3$).

vii. **Eye-flash:** during this behaviour, the eyebrows are lifted to expose the eyelids in a sudden jerky movement by pulling the forehead back. **Eye- flash and bared-teeth face:** eye flashing is sometimes followed by a bared-teeth face.

Both behaviours were frequently exhibited towards visitors, zoo staff or feral animals that pass the enclosure. Adults and sub-adults, especially hyper-aggressive socially-deprived males, exhibited these behaviours most frequently.

viii. **Fear grimace:** the individual opens its mouth slightly, with the corners of the lips pulled back so as to expose both rows of teeth. The teeth are parted only slightly and the jaws are not held open.

This behaviour was only displayed by adult and sub-adult females, sub-adult males and juveniles. Nine individuals exhibited this behaviour at a frequency of 0.3 ± 0.1 event/h.

ix. **Fear scream:** during an aggressive interaction, the target animal usually emits a loud screech-like high-pitched vocalisation.

Fear screams were exhibited by females and juveniles when another animal, usually a male, approached them aggressively or attacked them. This behaviour was exhibited approximately 2.1 ± 0.9 times an hour (N = 7).

x.**Flee:** this behaviour consists of an individual running away quickly from another individual in an agonistic situation. All age- and sex categories of individuals were observed to flee from adult males.

xi. **Lunge:** During certain agonistic situations, the aggressor charges and jumps forward towards a victim of aggression. This behaviour was only directed towards zoo staff and visitors, especially by hyper-aggressive socially-deprived males. These individuals invariably lunged towards the target human being only to be stopped by the cage bars.

xii. **Pull roughly:** pulling another individual roughly by any part of the body.

This behaviour was only exhibited by adult males towards females and juveniles. The target animal usually responded with a fear scream, fear grimace or lipsmacking. This behaviour was exhibited at an average frequency of 0.4 ± 0.2 event/h (N = 4).

xiii. **Push away:** pushing another individual away in an effort to avoid unwanted attention.

Push away was exhibited at a frequency of 0.2 ± 0.1 event/h (N = 3).

xiv. **Warning growl:** this low growl-like vocalisation is usually emitted during agonistic reactions.

Animals irrespective of age, sex or rearing history were observed exhibit this behaviour. Dominant animals were found to initiate agonistic interactions more frequently than did other individuals. Individuals were also observed to growl at other animals housed close to their enclosure when the latter started a disturbance.

2.2.4. Infant-related behaviours: these involve all the behaviours exhibited by a mother towards her infant. This category includes five behaviours defined below.

i. **Groom infant:** this involves the grooming of an infant by its mother usually to remove any foreign particles such as dirt, insects and ectoparasites from its hair.

ii. **Hold infant:** this involves holding an infant by its mother close to her body supporting it with either or both hands.

This behaviour was exhibited at a frequency of 0.3 ± 0.1 event/h (N = 2).

iii. **Pull infant:** this involves an infant being pulled by its mother close to her body.

Mothers were observed to pull infants close while moving, resting and foraging. Similar behaviours were exhibited by mothers during agonistic interactions, when infants fear-screamed or when visitors approached too close to infants. This behaviour was exhibited 0.3 ± 0.1 times an hour (N = 2).

iv. **Push infant:** this involves the mother pushing the infant away from herself.

This behaviour was more frequently exhibited towards infants over 10 months in age. Mothers also pushed their infants away when the infant interfered while they fed. One female exhibited this behaviour 0.73 times an hour towards her infant.

v. **Touch infant:** this involves the mother touching the infant gently.

Only one female exhibited this behaviour at a frequency of 0.4 event/h during this study.

2.2.5 Neutral behaviours: this category of behaviours are neither sexual in nature, nor affiliative or agonistic. There are eight behaviours in this category.

i. **Alert:** this behaviour involves an individual sitting or standing on any substratum and looking alertly at an object, individual or event in a particular direction.

The behaviour was exhibited at a frequency of 1.3 ± 0.2 event/h (N = 41), usually by adult males.

ii. **Allogrooming:** individuals groom any part of the body of another individual actively looking for fragments of dirt, insects, ectoparasites and other foreign particles in the hair.

Allogrooming bouts were initiated at a frequency of 1.8 ± 0.5 event/h (N = 22).

iii. **Approach:** this behaviour involves the actor approaching the target animal in which case the latter either ignores the actor, retreats or moves away. In several cases, the two individuals groom each other, mate or exhibit some other social interaction.

iv. **Avoid:** this behaviour involves staying away from particular animals. Usually subordinate animals retreat when dominant animals approach them.

Animals irrespective of age, sex or rearing history exhibited this behaviour at an average frequency of 0.2 ± 0.1 event/h (N = 2). Subordinate animals were observed to avoid certain parts of the enclosure in order to avoid dominant individuals.

v.**Ignore:** this behaviour involves an individual ignoring an interaction initiated by another animal.

This behaviour was often observed as a response to another individual presenting to the actor. Animals irrespective of age, sex or rearing history exhibited this behaviour at a frequency of 0.8 ± 0.3 event/h (N = 11).

vi. **Lip-smack:** this behaviour involves the vigorous repetitive movement of the lips against one another by the actor.

This behaviour was most often directed towards conspecifics, other animals housed in neighbouring enclosures, and also towards humans. Adult and sub-adult males were rarely observed to lip-smack. Females tended to lip-smack to males, subordinate animals to their dominant counterparts and young animals to the dominant male. Lipsmacking was exhibited at an average frequency of 1.5 ± 0.3 event/ h (N = 32). **Bipedal lip-smack:** sometimes individuals exhibited lipsmacking while standing bipedally on their hind limbs. One female housed at Mysore Zoo was observed to exhibit this behaviour only when she was off-exhibit. **Lip-smack with head-bobbing:** one individual was observed to exhibit lipsmacking while repeatedly bobbing her head up-and-down towards a target individual. She exhibited this behaviour at a frequency of 0.4 event/h.

vii. **Lost call:** a long, loud wail or moan by an individual probably exhibited when the individual is looking or searching for another animal.

This behaviour was exhibited 0.78 ± 0.2 times an hour (N = 10).

viii. **Retreat:** this behaviour involves the rapid moving away by an individual from the actor to maintain a certain distance from it, usually in response to aggression. Subordinate animals often retreat when dominant individuals approach them.

Animals irrespective of age, sex or rearing history exhibited this behaviour at a frequency of 0.9 ± 0.3 event/h (N = 18).

2.2.6 Play behaviours: these behaviours involve all actions of play. Animals irrespective of age, sex or rearing history exhibit this behaviour though infants, juveniles and sub-adults play more frequently. There are five behaviours in this category.

i. **Play bite:** this behaviour occurs when one animal playfully bites another gently on any part of the body.

This behaviour was usually exhibited along with other forms of play at a frequency of 0.8 ± 0.4 event/h (N = 4).

ii. **Play chase:** this behaviour involves one animal chasing the other. This is an affiliative interaction and usually ends in play fighting.

This behaviour was exhibited 1.4 ± 0.5 times an hour (N = 5) during this study.

iii. **Play fight:** this behaviour involves two individuals wrestling and tumbling with each other. This is most commonly seen among juveniles and infants, and is usually exhibited along with other forms of play.

Play fighting was exhibited at a frequency of 1.8 ± 0.5 event/h (N = 9).

iv. **Play jump:** this behaviour consists of an animal moving from one stratum to another by jumping instead of walking. This behaviour is usually observed in younger animals that have no playmates. Individuals also jump close to other animals to initial play.

This behaviour was exhibited 0.4 ± 0.2 times an hour (N = 4).

v.**Play slap:** this behaviour involves one individual slapping another playfully.

Play slap was usually exhibited along with other forms of play at a frequency of 0.9 ± 0.5 event/h (N = 3).

APPENDIX 4.2

Table A1. Differences between percentage behavioural categories exhibited tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different.

$R_{AB-RSTG}$[1] = 989.02[2]	$R_{RSTG-FF}$ = 804.25[2]	$R_{ACTIVE-NV}$ = 633.28[2]
$R_{AB-ACTIVE}$ = 450.45[2]	$R_{RSTG-AUTOG}$ = 1099.11[2]	$R_{FF-AUTOG}$ = 294.85[2]
R_{AB-FF} = 184.77[2]	$R_{RSTG-SOCIAL}$ = 1112.60[2]	$R_{FF-SOCIAL}$ = 308.34[2]
$R_{AB-AUTOG}$ = 110.09[2]	$R_{RSTG-NV}$ = 1171.85[2]	R_{FF-NV} = 367.60[2]
$R_{AB-SOCIAL}$ = 123.58[2]	$R_{ACTIVE-FF}$ = 265.68[2]	$R_{AUTOG-SOCIAL}$ = 13.49[2]
R_{AB-NV} = 182.83[2]	$R_{ACTIVE-AUTOG}$ = 560.53[2]	$R_{AUTOG-NV}$ = 72.75[2]
$R_{RSTG-ACTIVE}$ = 538.57[2]	$R_{ACTIVE-SOCIAL}$ = 574.02[2]	$R_{SOCIAL-NV}$ = 59.26[2]

[1]Where AB =Abnormal behaviour, RSTG =Rest behaviour, ACTIVE =Active behaviour, FF =Food-related behaviour, AUTOG =Autogrooming, SOCIAL =Social behaviour and NV =Not visible
[2]Significant at $Z_{\alpha/k(k-1)}$=3.038, α =0.05, K =7 and N =26 (groups of captive lion-tailed macaques).

Table A2. Influence of rearing history on stand (SR), climb (CLR) and cough (Co) tested by using Kruskal-Wallis one-way analysis. This table consists of the post-hoc pair-wise comparison of behaviours to determine the pairs that are significantly different.

SR_{CR-ZB}[1] = 8.18	SR_{CR-CF} = 0.07	SR_{ZB-CF} = 8.11[2]
CLR_{CR-ZB}[1] = 6.91	CLR_{CR-CF} = 0.79	CL_{ZB-CF} = 7.70[2]
CoR_{CR-ZB}[1] = 4.68	CoR_{CR-CF} = 9.62[2]	CoR_{ZB-CF} = 4.49

[1]Where CR =Captive reared individuals, ZB =Zoo born, CF =Confiscated, for definitions of these terms refer to Table 2.4 in Chapter II General Methods
[2]Significant at $Z_{\alpha/k(k-1)}$=2.394, α =0.05, K =3 and N =26 (groups of captive lion-tailed macaques).

Table A3. Influence of enclosure complexity on active foraging (CR) and enclosure type on passive foraging (TR) tested by using Kruskal-Wallis one-way analysis. This table consists of the post-hoc pair-wise comparison of behaviours to determine the pairs that are significantly different.

CR_{BA-BE}[1] = 4.72	CR_{BA-CO} = 9.53	CR_{BE-CO} = 4.82[2]
TR_{CA-WM}[1] = 12.6[2]	TR_{CA-DM} = 14.00[2]	TR_{WM-DM} = 1.40

[1]Where BA = Barren enclosures, BE = Barren but enriched, CO = Complex, CA = Cage, WM = Wet-moated, DR = Dry-moated for the definitions of these terms refer to Table 2.4 in Chapter II *General Methods*
[2]Significant at $Z_{\alpha/k(k-1)}$=2.394, α =0.05, K =3 and N =26 (groups of captive lion-tailed macaques).

Table A4. Influence of enclosure size on ignore (SR) and feeding regime on present with lipsmacking (PR) and move away (MR) tested by using Kruskal-Wallis one-way analysis. This table consists of the post-hoc pair-wise comparison of behaviours to determine the pairs that are significantly different

SR_{1-2}[1] = 3.29	SR_{1-3} = 3.96	SR_{1-4} = 6.31
SR_{2-3} = 7.25[2]	SR_{2-4} = 9.60[2]	SR_{3-4} = 2.35
PR_{1-2}[1] = 3.50	PR_{1-3} = 6.67	PR_{1-4} = 1.00
PR_{1-5} = 11.00	PR_{1-6} = 13.94[2]	PR_{2-3} = 3.17
PR_{2-4} = 4.50	PR_{2-5} = 7.50	PR_{2-6} = 10.44
PR_{3-4} = 7.67	PR_{3-5} = 4.33	PR_{3-6} = 7.27
PR_{4-5} = 12.00[3]	PR_{4-6} = 14.94[3]	PR_{5-6} = 2.94
MR_{1-2} = 8.10	MR_{1-3} = 3.50	MR_{1-4} = 11.50
MR_{1-5} = 0.00	MR_{1-6} = 0.000	MR_{2-3} = 4.60
MR_{2-4} = 3.40	MR_{2-5} = 8.10	MR_{2-6} = 8.10
MR_{3-4} = 8.00	MR_{3-5} = 3.50	MR_{3-6} = 3.50
MR_{4-5} = 11.50[3]	MR_{4-6} = 11.50[3]	MR_{5-6} = 0.00

[1]For SR, refer ranks for enclosure size & for PR & MR to ranks for feeding regime in Table 2.4 in Chapter II *General Methods*
[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =26 (groups of captive lion-tailed macaques).
[3]Significant at $Z_{\alpha/k(k-1)}$=2.935, α =0.05, K =6 and N =26 (groups of captive lion-tailed macaques).

Table A5. Differences between percentage time spent in each enclosure zone tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different.

$R_{ED\text{-}ENR}$[1] = 185.09[2]	$R_{ED\text{-}OT}$ = 303.60[2]	$R_{ED\text{-}BC}$ = 815.49[2]
$R_{ENR\text{-}OT}$ = 118.51[2]	$R_{ENR\text{-}BC}$ = 630.40[2]	$R_{OT\text{-}BC}$ = 511.89[2]

[1]Where ED =Edge, ENR =enrich, OT =Other, BC =back zones

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K = 4 and N =26 (groups of captive lion-tailed macaques).

Table A6. Influence of enclosure complexity on the use of the edge zone (CR) and enclosure size on the use of the back zone (SR) tested by using Kruskal-Wallis one-way analysis. This table consists of the post-hoc pair-wise comparison of behaviours to determine the pairs that are significantly different

$CR_{BA\text{-}BE}$[1] = 7.3	$CR_{BA\text{-}CO}$ = 13.71[2]	$CR_{BE\text{-}CO}$ = 6.41
$SR_{1\text{-}2}$[3] = 12.12[4]	$SR_{1\text{-}3}$ = 4.94	$SR_{1\text{-}4}$ = 10.96
$SR_{2\text{-}3}$ = 7.18	$SR_{2\text{-}4}$ = 1.16	$SR_{3\text{-}4}$ = 6.02

[1]Where BA =Barren enclosures, BE =barren but enriched, CO =Complex, for definitions of these terms refer to Table 2.4 in Chapter II *General Methods*

[2]Significant at $Z_{\alpha/k(k-1)}$=2.394, α =0.05, K =3 and N =26 (groups of captive lion-tailed macaques).

[3]Refer ranks for enclosure size in Table 2.4 in Chapter II *General Methods*

[4]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =26 (groups of captive lion-tailed macaques).

APPENDIX 5.1

Table A1. Differences between percentage behavioural state categories exhibited during the five phases of the structural enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. BR = Barren, RPR = Barren + ropes, RBR = Barren + ropes + basket, MBR = Basket removed and MPR = Ropes removed

BR $_{AB^1\text{-}ACTIVE}$=46.15[2]	BR $_{AB\text{-}RSTG}$=153.85[2]	BR $_{AB\text{-}FF}$=38.46[2]
BR $_{ACTIVE\text{-}RSTG}$=200.00[2]	BR $_{ACTIVE\text{-}FF}$=84.62[2]	BR $_{RSTG\text{-}FF}$=56.92[2]
RPR $_{AB\text{-}ACTIVE}$=227.13[2]	RPR $_{AB\text{-}RSTG}$=33.81[2]	RPR $_{AB\text{-}FF}$=117.81[2]
RPR $_{ACTIVE\text{-}RSTG}$=260.93[2]	RPR $_{ACTIVE\text{-}FF}$=109.31[2]	RPR $_{RSTG\text{-}FF}$=13.00
RBR $_{AB\text{-}ACTIVE}$=131.28[2]	RBR $_{AB\text{-}RSTG}$=62.05[2]	RBR $_{AB\text{-}FF}$=110.26[2]
RBR $_{ACTIVE\text{-}RSTG}$=193.33[2]	RBR $_{ACTIVE\text{-}FF}$=21.03[2]	RBR $_{RSTG\text{-}FF}$=172.31[2]
MBR $_{AB\text{-}ACTIVE}$=162.54[2]	MBR $_{AB\text{-}RSTG}$=17.43[2]	MBR $_{AB\text{-}FF}$=135.09[2]
MBR $_{ACTIVE\text{-}RSTG}$=179.97[2]	MBR $_{ACTIVE\text{-}FF}$=27.45[2]	MBR $_{RSTG\text{-}FF}$=152.51[2]
MPR $_{AB\text{-}ACTIVE}$=193.07[2]	MPR $_{AB\text{-}RSTG}$=17.03[2]	MPR $_{AB\text{-}FF}$=190.45[2]
MPR $_{ACTIVE\text{-}RSTG}$=210.10[2]	MPR $_{ACTIVE\text{-}FF}$=2.62[2]	MPR $_{RSTG\text{-}FF}$=207.48[2]

[1]Where AB =Abnormal behaviour, RSTG =Rest behaviour, ACTIVE =Active behaviour and FF =Food-related behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =6 (groups of captive lion-tailed macaques).

Table A2. Differences between percentage behavioural event categories exhibited during the five phases of the structural enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. (BR = Barren, RPR = Barren + ropes, RBR = Barren + ropes + basket, MBR = Basket removed and MPR = Ropes removed)

BR $_{REP^1\text{-}AFF}$=55.44[2]	BR $_{REP\text{-}AGG}$=74.12[2]	BR $_{REP\text{-}AB}$=18.68[2]
BR $_{AFF\text{-}AGG}$=39.87[2]	BR $_{AFF\text{-}AB}$=15.56[2]	BR $_{AGG\text{-}AB}$=34.25[2]
RPR $_{REP\text{-}AFF}$=72.18[2]	RPR $_{REP\text{-}AGG}$=137.06[2]	RPR $_{REP\text{-}AB}$=37.90[2]
RPR $_{AFF\text{-}AGG}$=64.88[2]	RPR $_{AFF\text{-}AB}$=34.28[2]	RPR $_{AGG\text{-}AB}$=99.15[2]
RBR $_{REP\text{-}AFF}$=48.01[2]	RBR $_{REP\text{-}AGG}$=175.80[2]	RBR $_{REP\text{-}AB}$=23.09[2]
RBR $_{AFF\text{-}AGG}$=127.89[2]	RBR $_{AFF\text{-}AB}$=24.92[2]	RBR $_{AGG\text{-}AB}$=152.81[2]
MBR $_{REP\text{-}AFF}$=43.67[2]	MBR $_{REP\text{-}AGG}$=122.48[2]	MBR $_{REP\text{-}AB}$=31.33[2]
MBR $_{AFF\text{-}AGG}$=78.81[2]	MBR $_{AFF\text{-}AB}$=12.33[2]	MBR $_{AGG\text{-}AB}$=91.14[2]
MPR $_{REP\text{-}AFF}$=72.50[2]	MPR $_{REP\text{-}AGG}$=132.75[2]	MPR $_{REP\text{-}AB}$=54.14[2]
MPR $_{AFF\text{-}AGG}$=60.25[2]	MPR $_{AFF\text{-}AB}$=18.36[2]	MPR $_{AGG\text{-}AB}$=78.61[2]

[1]Where REP =reproductive behaviour, AGG =aggressive behaviour, AFF =Affiliative behaviour and AB =abnormal behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =6 (groups of captive lion-tailed macaques).

Table A3. Differences between percentage behavioural states (SR – sleep, ABR –total abnormal behaviour) and behavioural events exhibited during the five phases of the structural enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. abR – frequency of total abnormal behaviour, RR – rope chewing, SWR – attempted swing, SBR – self-biting and ER – exploratory behaviour

SR $_{\text{B}^{1}\text{-RP}}$ = 18.02[2]	SR $_{\text{B-RB}}$ = 20.51[2]	SR $_{\text{B-MB}}$ = 1.96
SR $_{\text{B-MP}}$ = 1.89	SR $_{\text{RP-RB}}$ = 2.50	SR $_{\text{RP-MB}}$ = 16.06[2]
SR $_{\text{RP-MP}}$ = 16.13[2]	SR $_{\text{RB-MB}}$ = 18.55[2]	SR $_{\text{RB-MP}}$ = 18.63[2]
SR $_{\text{MB-MP}}$ = 0.07		
ABR $_{\text{B-RP}}$ = 5.47	ABR $_{\text{B-RB}}$ = 65.64[2]	ABR $_{\text{B-MB}}$ = 7.84
ABR $_{\text{B-MP}}$ = 3.63	ABR $_{\text{RP-RB}}$ = 60.18[2]	ABR $_{\text{RP-MB}}$ = 13.30[2]
ABR $_{\text{RP-MP}}$ = 1.84	ABR $_{\text{RB-MB}}$ = 73.48[2]	ABR $_{\text{RB-MP}}$ = 62.01[2]
ABR $_{\text{MB-MP}}$ = 11.47		
abR $_{\text{B-RP}}$ = 4.18	abR $_{\text{B-RB}}$ = 16.96[2]	abR $_{\text{B-MB}}$ = 18.06[2]
abR $_{\text{B-MP}}$ = 0.65	abR $_{\text{RP-RB}}$ = 21.14[2]	abR $_{\text{RP-MB}}$ = 13.88
abR $_{\text{RP-MP}}$ = 3.53	abR $_{\text{RB-MB}}$ = 35.02[2]	abR $_{\text{RB-MP}}$ = 17.61[2]
abR $_{\text{MB-MP}}$ = 17.41[2]		
RR $_{\text{B-RP}}$ = 12.91	RR $_{\text{B-RB}}$ = 18.56[2]	RR $_{\text{B-MB}}$ = 34.59[2]
RR $_{\text{B-MP}}$ = 23.51[2]	RR $_{\text{RP-RB}}$ = 5.65	RR $_{\text{RP-MB}}$ = 21.68[2]
RR $_{\text{RP-MP}}$ = 10.60	RR $_{\text{RB-MB}}$ = 16.03[2]	RR $_{\text{RB-MP}}$ = 4.95
RR $_{\text{MB-MP}}$ = 11.08		
SWR $_{\text{B-RP}}$ = 0.88	SWR $_{\text{B-RB}}$ = 20.50[2]	SWR $_{\text{B-MB}}$ = 0.91
SWR $_{\text{B-MP}}$ = 2.14	SWR $_{\text{RP-RB}}$ = 19.62[2]	SWR $_{\text{RP-MB}}$ = 0.03
SWR $_{\text{RP-MP}}$ = 1.26	SWR $_{\text{RB-MB}}$ = 19.59[2]	SWR $_{\text{RB-MP}}$ = 18.36[2]
SWR $_{\text{MB-MP}}$ = 1.33		
SBR $_{\text{B-RP}}$ = 2.4	SBR $_{\text{B-RB}}$ = 19.67[2]	SBR $_{\text{B-MB}}$ = 17.62[2]
SBR $_{\text{B-MP}}$ = 0.14	SBR $_{\text{RP-RB}}$ = 16.53[2]	SBR $_{\text{RP-MB}}$ = 2.05
SBR $_{\text{RP-MP}}$ = 19.53[2]	SBR $_{\text{RB-MB}}$ = 3.14	SBR $_{\text{RB-MP}}$ = 17.48[2]
SBR $_{\text{MB-MP}}$ = 16.39[2]		
ER $_{\text{B-RP}}$ = 9.01	ER $_{\text{B-RB}}$ = 22.36[2]	ER $_{\text{B-MB}}$ = 1.80
ER $_{\text{B-MP}}$ = 2.34	ER $_{\text{RP-RB}}$ = 24.70[2]	ER $_{\text{RP-MB}}$ = 10.81
ER $_{\text{RP-MP}}$ = 10.81	ER $_{\text{RB-MB}}$ = 11.35	ER $_{\text{RB-MP}}$ = 24.16[2]
ER $_{\text{MB-MP}}$ = 13.35		

[1]B = Barren, RP = Barren + ropes, RB = Barren + ropes + basket, MB = Basket removed & MP = Ropes removed
[2]Significant at $Z_{\alpha/k(k-1)}$=2.807, α =0.05, K = 5 and N = 6 (captive lion-tailed macaque individuals).

Table A4. Differences between percentage space used during the five phases (BR = Barren, RPR = Barren + ropes, RBR = Barren + ropes + basket, MBR = Basket removed and MPR = Ropes removed) of the structural enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different.

BR $_{\text{ED-ENR}}$ = 253.84[2]	BR $_{\text{ED-OT}}$ = 84.61[2]	BR $_{\text{ED-BC}}$ = 138.46[2]
BR $_{\text{ENR-OT}}$ = 169.23[2]	BR $_{\text{ENR-BC}}$ = 115.23[2]	BR $_{\text{OT-BC}}$ = 53.85[2]
RPR $_{\text{ED-ENR}}$ = 220.33[2]	RPR $_{\text{ED-OT}}$ = 184.20[2]	RPR $_{\text{ED-BC}}$ = 57.87[2]
RPR $_{\text{ENR-OT}}$ = 36.13[2]	RPR $_{\text{ENR-BC}}$ = 162.46[2]	RPR $_{\text{OT-BC}}$ = 126.33[2]
RBR $_{\text{ED-ENR}}$ = 214.21[2]	RBR $_{\text{ED-OT}}$ = 168.05[2]	RBR $_{\text{ED-BC}}$ = 126.02[2]
RBR $_{\text{ENR-OT}}$ = 46.16[2]	RBR $_{\text{ENR-BC}}$ = 88.19[2]	RBR $_{\text{OT-BC}}$ = 42.03[2]
MBR $_{\text{ED-ENR}}$ = 246.36[2]	MBR $_{\text{ED-OT}}$ = 123.05[2]	MBR $_{\text{ED-BC}}$ = 85.62[2]
MBR $_{\text{ENR-OT}}$ = 123.31[2]	MBR $_{\text{ENR-BC}}$ = 160.74[2]	MBR $_{\text{OT-BC}}$ = 37.43[2]
MPR $_{\text{ED-ENR}}$ = 126.17[2]	MPR $_{\text{ED-OT}}$ = 75.90[2]	MPR $_{\text{ED-BC}}$ = 12.31[2]
MPR $_{\text{ENR-OT}}$ = 50.27[2]	MPR $_{\text{ENR-BC}}$ = 113.86[2]	MPR $_{\text{OT-BC}}$ = 63.59[2]

[1]Where ED =Edge, ENR =enrich, OT =Other, BC =back zones
[2]Significant at $Z_{\alpha/k(k-1)}$=3.038, α =0.05, K =7 and N =26 (groups of captive lion-tailed macaques).

Table A5. Differences between frequencies of behavioural categories exhibited during the two phases of the social enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. GR = group housed and IR = singly-housed

$GR_{REP^1\text{-}AFF}=32.36^2$	$GR_{REP\text{-}AGG}=3.11^2$	$GR_{REP\text{-}AB}=47.10^2$
$GR_{AFF\text{-}AGG}=50.20^2$	$GR_{AFF\text{-}AB}=35.46^2$	$GR_{AGG\text{-}AB}=14.74^2$
$IR_{REP\text{-}AFF}=58.68^2$	$IR_{REP\text{-}AGG}=62.22^2$	$IR_{REP\text{-}AB}=25.57^2$
$IR_{AFF\text{-}AGG}=120.90^2$	$IR_{AFF\text{-}AB}=84.25^2$	$IR_{AGG\text{-}AB}=36.65^2$

[1]Where REP =reproductive behaviour, AGG =aggressive behaviour, AFF =Affiliative behaviour and AB =abnormal behaviour

[2]Significant at $Z_{\alpha/k(k-1)}=2.638$, $\alpha=0.05$, K =4 and N =7 (groups of captive lion-tailed macaques).

Table A6. Differences between percentage time spent in enclosure zones during the two phases (GR = group housed and IR = singly-housed) of the social enrichment study tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different.

$GR_{ED\text{-}ENR}=29.58^2$	$GR_{ED\text{-}OT}=235.58^2$	$GR_{ED\text{-}BC}=219.73^2$
$GR_{ENR\text{-}OT}=205.60^2$	$GR_{ENR\text{-}BC}=190.15^2$	$GR_{OT\text{-}BC}=15.45^2$
$IR_{ED\text{-}ENR}=73.94^2$	$IR_{ED\text{-}OT}=11.68^2$	$IR_{ED\text{-}BC}=22.54^2$
$IR_{ENR\text{-}OT}=62.27^2$	$IR_{ENR\text{-}BC}=96.49^2$	$IR_{OT\text{-}BC}=34.22^2$

[1]Where ED =Edge, ENR =enrich, OT =Other, BC =back zones

[2]Significant at $Z_{\alpha/k(k-1)}=3.038$, $\alpha=0.05$, K =7 and N =26 (groups of captive lion-tailed macaques).

APPENDIX 6.1

Table A1. Differences between percentage behavioural state categories exhibited during the two phases of the visitor influence study [Study 1A] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. VPR = 'visitor presence', VAR = 'visitor absence'

VPR $_{AB-RSTG}$ = 307.76[2]	VPR $_{RSTG-ACTIVE}$ = 129.63[2]	VPR $_{ACTIVE-FF}$ = 566.75[2]
VPR $_{AB-ACTIVE}$ = 178.13[2]	VPR $_{RSTG-FF}$ = 437.12[2]	VPR $_{FF-SOCIAL}$ = 210.47[2]
VPR $_{AB-FF}$ = 744.88[2]	VPR $_{RSTG-SOCIAL}$ = 340.10[2]	VPR $_{FF-SOCIAL}$ = 777.22[2]
VPR $_{AB-SOCIAL}$ = 32.34[2]		
VAR $_{AB-RSTG}$ = 322.41[2]	VAR $_{RSTG-ACTIVE}$ = 146.61[2]	VAR $_{ACTIVE-FF}$ = 594.60[2]
VAR $_{AB-ACTIVE}$ = 176.00[2]	VAR $_{RSTG-FF}$ = 447.99[2]	VAR $_{FF-SOCIAL}$ = 181.26[2]
VAR $_{AB-FF}$ = 770.60[2]	VAR $_{RSTG-SOCIAL}$ = 327.87[2]	VAR $_{FF-SOCIAL}$ = 775.86[2]
VAR $_{AB-SOCIAL}$ = 5.26		

[1]Where AB =Abnormal behaviour, RSTG =Rest behaviour, ACTIVE =Active behaviour, FF =Food-related behaviour and SOCIAL =Social behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.807, α =0.05, K =5 and N =15 (groups of captive lion-tailed macaques).

Table A2. Differences between percentage behavioural event categories exhibited during the two phases of the visitor influence study [Study 1A] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. VPR = 'visitor presence', VAR = 'visitor absence'

VPR $_{REP-AFF}$ =60.97[2]	VPR $_{REP-AGG}$ =15.73	VPR $_{REP-AB}$ =0.97
VPR $_{AFF-AGG}$ =45.24[2]	VPR $_{AFF-AB}$ =61.93[2]	VPR $_{AGG-AB}$ =16.69
VAR $_{REP-AFF}$ =45.60[2]	VAR $_{REP-AGG}$ =35.23[2]	VAR $_{REP-AB}$ =4.74
VAR $_{AFF-AGG}$ =10.38[2]	VAR $_{AFF-AB}$ =50.35[2]	VAR $_{AGG-AB}$ =39.97[2]

[1]Where REP =reproductive behaviour, AGG =aggressive behaviour, AFF =Affiliative behaviour and AB =abnormal behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =15 (groups of captive lion-tailed macaques).

Table A3. Differences between percentage behavioural state categories exhibited during the two phases of the visitor influence study [Study 1B] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. ONR = 'on-exhibit', OFR = 'off-exhibit'

ONR $_{AB-RSTG}$ =31.65[2]	ONR $_{RSTG-ACTIVE}$ = 330.36[2]	ONR $_{ACTIVE-FF}$ = 187.86[2]
ONR $_{AB-ACTIVE}$ =141.06[2]	ONR $_{RSTG-FF}$ = 298.71[2]	ONR $_{FF-SOCIAL}$ = 156.21[2]
ONR $_{AB-FF}$ =109.41[2]	ONR $_{RSTG-SOCIAL}$ = 142.50[2]	ONR $_{FF-SOCIAL}$ = 189.30[2]
ONR $_{AB-SOCIAL}$ =46.80[2]		
OFR $_{AB-RSTG}$ =97.71[2]	OFR $_{RSTG-ACTIVE}$ = 266.68[2]	OFR $_{ACTIVE-FF}$ = 250.53[2]
OFR $_{AB-ACTIVE}$ = 65.68[2]	OFR $_{RSTG-FF}$ = 169.27[2]	OFR $_{FF-SOCIAL}$ = 152.86[2]
OFR $_{AB-FF}$ = 32.03[2]	OFR $_{RSTG-SOCIAL}$ = 16.45[2]	OFR $_{FF-SOCIAL}$ = 201.30[2]
OFR $_{AB-SOCIAL}$ = 184.85[2]		

[1]Where AB =Abnormal behaviour, RSTG =Rest behaviour, ACTIVE =Active behaviour, FF =Food-related behaviour and SOCIAL =Social behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.807, α =0.05, K =5 and N =7 (captive lion-tailed macaque individuals).

Table A4. Differences between percentage behavioural event categories exhibited during the two phases of the visitor influence study [Study 1B] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. ONR = 'on-exhibit', OFR = 'off-exhibit'

$ONR_{REP\text{-}AFF} = 19.02^{2}$	$ONR_{REP\text{-}AGG} = 72.03^{2}$	$ONR_{REP\text{-}AB} = 49.40^{2}$
$ONR_{AFF\text{-}AGG} = 53.01^{2}$	$ONR_{AFF\text{-}AB} = 68.42^{2}$	$ONR_{AGG\text{-}AB} = 121.43^{2}$
$OFR_{REP\text{-}AFF} = 35.17^{2}$	$OFR_{REP\text{-}AGG} = 33.87^{2}$	$OFR_{REP\text{-}AB} = 2.78$
$OFR_{AFF\text{-}AGG} = 69.04^{2}$	$OFR_{AFF\text{-}AB} = 37.95^{2}$	$OFR_{AGG\text{-}AB} = 31.09^{2}$

[1]Where REP =reproductive behaviour, AGG =aggressive behaviour, AFF =Affiliative behaviour and AB =abnormal behaviour

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =7 (captive lion-tailed macaque individuals).

Table A5. Differences between percentage time spent in each enclosure zone on-exhibit during the visitor influence study [Study 1B] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different.

$R_{ED\text{-}ENR} = 110.91^{2}$	$R_{ED\text{-}OT} = 21.03^{2}$	$R_{ED\text{-}BC} = 423.09^{2}$
$R_{ENR\text{-}OT} = 131.94^{2}$	$R_{ENR\text{-}BC} = 312.18^{2}$	$R_{OT\text{-}BC} = 444.12^{2}$

[1]Where ED =Edge, ENR =enrich, OT =Other, BC =back zones

[2]Significant at $Z_{\alpha/k(k-1)}$=2.638, α =0.05, K =4 and N =7 (captive lion-tailed macaque individuals).

Name of Zoo: *Date:*

APPENDIX 6.2. FOR CHAPTER 6

VISITOR PERCEPTION AND EDUCATION

1. Number of people in your group visiting the zoo

Children	Adults	Total

2. Number of working members in the group
Number in the group that are educated up to

School	Graduate	Profession

Which city or village are you from?

3. Have you visited this zoo before?

Yes	No

If yes, how many times have you visited this zoo before?

4. Did you see the lion-tailed macaques in the zoo?

Yes	No

If yes, continue; if no, go to Question 12

5. Describe the appearance of the lion-tailed macaque

6. Do they live in groups in the jungle? Yes or No
Are they housed in groups in the zoo? Yes or No

7. Which part of India are lion-tailed macaques found in?

8. Describe the habitat in which lion-tailed macaques live

9. Should lion-tailed macaques and their habitat be protected? If yes, why?

10. Did you like the lion-tailed macaque exhibit? If yes, why?

11. Did you enjoy your visit to the zoo and why?

Name of Zoo: ***Date:***

12. Did you notice anything interesting about the behaviour in the lion-tailed macaques in the zoo?

13. Do you interact and feed animals while you are at the zoo? Do you think interacting with animals could affect the animal's welfare?

14. Would you rate your visit as entertaining, educative, both or neither? Give reasons and suggest what changes you would like to see

15. What are the goals of a zoo according to you?

16. Can zoos help save our wildlife and environment? Explain

Name of Zoo: *Date:*

APPENDIX 6.3. FOR CHAPTER 6

PUBLIC PERCEPTION

1. Have you seen a lion-tailed macaque either in a zoo or in the wild? **Yes** **No**

   If yes, continue; if no, go to Question 6

2. Describe the appearance of the lion-tailed macaque

3. Do they live in groups in the jungle? **Yes or No**
4. In which part of India do lion-tailed macaques live?
5. Describe the habitat of the lion-tailed macaque

6. Should the lion-tailed macaque and its habitat be protected?

7. Did you know of any other species live in the lion-tails habitat? Name them

8. Where are rainforests located in India?

APPENDIX 7.1

Table A1. Differences between percentage behavioural event categories exhibited during the two phases of the visitor influence study [Study 1A] tested by using Friedman's two-way analysis of variance. This table consists of the post-hoc pair-wise comparison of behavioural categories to determine the pairs that are significantly different. VPR = 'visitor presence', VAR = 'visitor absence'

$VPR_{REP-AFF}=60.97^2$	$VPR_{REP-AGG}=15.73$	$VPR_{REP-AB}=0.97$
$VPR_{AFF-AGG}=45.24^2$	$VPR_{AFF-AB}=61.93^2$	$VPR_{AGG-AB}=16.69$
$VAR_{REP-AFF}=45.60^2$	$VAR_{REP-AGG}=35.23^2$	$VAR_{REP-AB}=4.74$
$VAR_{AFF-AGG}=10.38^2$	$VAR_{AFF-AB}=50.35^2$	$VAR_{AGG-AB}=39.97^2$

[1]Where REP =reproductive behaviour, AGG =aggressive behaviour, AFF =Affiliative behaviour and AB =abnormal behaviour

[2]Significant at $Z_{\alpha/k(k-1)}=2.638$, $\alpha=0.05$, $K=4$ and $N=15$ (groups of captive lion-tailed macaques).